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ORIGINAL ARTICLES.

The Cretaceous Limestones of Jamaica and their Mollusca.

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(PLATES XXII–XXVI.)

Introduction.

MOST of the exposures of Cretaceous Limestone in Jamaica were faithfully indicated on the Geological Survey map of Sawkins and Brown in 1865.[1] They are limited in extent and occur at certain places among the complex of the older or Blue Mountain series of rocks that project from beneath the covering of White Limestone that covers the greater part of the Island. Contrary to one's common experience in many European countries the Cretaceous beds in Jamaica do not approach the sea coast in any part except near Port Antonio on the north-east coast, where the Trappean shales reach the sea ; near St. Ann's Bay, about the centre ; and at Green Island, on the north-west coast, where the Barrettia Limestone occurs within 2 miles of the sea. Elsewhere the sea coast is occupied by the White Limestone or beds that overlie it, with the exception of stretches along the north coast around Lucea Harbour and between Port Maria and Annotta Bay, occupied by the Carbonaceous Shales of Lower Eocene age.

Having examined most of the Cretaceous Limestone outcrops in Jamaica, I feel competent to offer some information on their stratigraphy and palaeontology which may be of use to geologists. Ample material for one or more monographs on the Cretaceous and Eocene faunas exists in Jamaica, but as there seems no possibility of such forthcoming in the near future, a summary of the more interesting results obtained may be given. The fossils dealt with in this paper are mainly the Rudist mollusca, but it is hoped that one dealing with the Gasteropoda and remaining Lamellibranchiata may follow later.

Starting at the extreme west of the Island and proceeding eastwards, the exposures described or referred to are as follows :—

[1] " Reports on the Geology of Jamaica " : *Mem. Geol. Surv. London*, 1869.

Western Jamaica.

Jerusalem Mountain, near the estate of Mint (Westmoreland Parish).
Green Island, or Haughton Hall (Hanover Parish).
Cambridge and Catadupa railway cuttings (St. James Parish).
Valley of the Great River (St. James Parish).
Malden and Valley of the Tangle River (St. James Parish).

Central Jamaica.

Logie Green, White Rock River, Trout Hall, Smithville, Mount Hindmost, and other places in the watershed of the Rio Minho (Clarendon Parish).
Mount Diablo (doubtfully Cretaceous) (St. Thomas-in-the-Vale Parish).
Guy's Hill and adjacent localities (Metcalfe Parish).
St. Ann's Great River Valley (St. Ann Parish).

Eastern Jamaica.

The Back River and neighbouring outcrops (Portland Parish).
Providence, near Port Antonio (Portland Parish).
Mooretown and adjacent valley of the Rio Grande (Portland Parish).
The Plantain Garden River (St. Thomas in the East Parish).

The beds described herein include part of R. T. Hill's [1] Cambridge and Catadupa formations, together with his Ballard, Logie Green, Frankenfield, Jerusalem, and Yallahs Formations. In his map Hill indicates patches of Cretaceous Limestone on the south-east coast where I have failed to trace any in reality. His Yallahs Formation seems to me to be the Carbonaceous Shale of Eocene date.

Jerusalem Mountain.

The extreme west end of Jamaica consists of flat or undulating country, from which a number of conical or spreading hills stand out. Jerusalem Mountain, as it is called, comprises an elevated mass about 3 miles long, rising to 580 feet, thickly covered in places with bamboos, and largely given over to cultivation, the residue of the marly limestones appearing very suitable for this purpose. Adjacent to it on the east stand several conical, more or less precipitous, thickly wooded hills of White Limestone. The triangular outline of the Cretaceous outcrop and the nearness of the hills of Tertiary limestone suggest that its boundaries on one or more sides may be faulted, but more detailed mapping will be required to determine this. The massif, which is somewhat deeply dissected by stream erosion, seems to me to have a dome-shaped anticlinal structure. Beds on the eastern side of it dip a few degrees eastwards at an angle that nearly coincides with the slope of the hill and of a road that leads up it. R. T. Hill places the Jerusalem beds low down

[1] "Geol. and Phys. Geogr. of Jamaica": *Bull. Mus. Comp. Zool. Harvard*, vol. xxxiv, 1899, p. 42.

in his section of Cretaceous rocks, and remarks that they consist of extensive limestone beds. The limestones, however, are not particularly massive, and are divided by several beds of shale and conglomerate. The fairly massive limestone that caps the hill and contains an oyster very much resembling *Ostrea arizpensis* of Mexico, far from being low in the sequence, may, I think, be the highest Cretaceous Limestone in Jamaica. The following section of about 250 feet of beds represents the sequence, as I observed it, from the eastern foot up to the summit of the hill :—

	Approximate thickness in feet.
Massive grey foraminiferal limestone with numerous Alectryonate Oysters (*Ostrea arizpensis* var. *jamaicensis*) and occasional *Radiolites* very strongly incorporated in the rock. This bed caps the hill and weathers into sharp jagged surfaces or Karst structure	40–50
Red shale	(?)
Trappean conglomerate made of rounded pebbles . .	20 (?)
Red shale with small nodular concretions	(?)
Limestone with *Ostrea*, small *Plagioptychus*, and *Biradiolites* cf. *cancellatus*	6
Red and grey shale	(?)
Yellow coloured limestone full of small *Actaeonellae* (*A.* cf. *acutissima*) and other fossils	10
Grey shale and marl	(?)
Grey nodular impure marly limestone with numerous very large *Titanosarcolites* (*Caprinula* Whitf.) *gigantea* lying flat along the bedding planes, some with both valves together 5 or 6 feet long ; a fragment of *Diploria conferticostata* and other corals	30–40
Grey shale with limestone nodules and small *Plagioptychi* .	20 (?)
Shaley limestone	10
Grey nodular shale	20
Red shale	5
Red pebbly trappean conglomerate (base not seen) . .	(?)

Green Island.

I have already published a description of the Cretaceous beds at Green Island or Haughton Hall [1] and of the fauna that occurs there. The most conspicuous fossils in the limestone are the *Barrettiae*. As the result of subsequent visits to the locality, I have little to add to the account of the stratigraphy, and only one or two additional species of mollusca to record, a list of which will be found further on.

Cambridge and Catadupa Railway Cutting and Valley of the Great River.

I have already published a sketch of the section of Cretaceous and Tertiary beds extending for a distance of about 3 miles along this railway cutting in a paper dealing with the Cretaceous and Tertiary question in Jamaica.[2] A bed of Rudist Limestone about 40 feet thick

[1] "The *Barrettia* Beds of Jamaica" : Geol. Mag., Vol. LIX, Nov., 1922, pp. 501–14.

[2] Geol. Mag., Vol. LIX, No. 699, Sept., 1922, pp. 422–31.

here follows closely upon an underlying bed of shale, which contains a group of mollusca of Campanian aspect, similar in many species to that in the Providence shales near Port Antonio, where, in addition, Ammonites and Baculites also occur.

Cretaceous Limestone resembling that in the adjacent railway cutting occupies both sides of the broad and deep valley of the Great River, where beds of it 40–50 feet thick occur, and afford excellent exposures both along the river and towards Seaford Town to the west. They are yellow and marly in some places, but grey and compact in others, and yield numerous fossils in most of the exposures. They overlie a very considerable thickness of red shale in which in one place on the south side of the valley opposite Catadupa I found some specimens of a *Cardium*, but elsewhere the shales that underlie the limestones seem to be very unfossiliferous. For some miles up the Great River Valley the Cretaceous Limestones are repeatedly exposed, and comprise several beds of grey limestone and marl interbedded with shales and sandy clays, all of them much cut by faults. Still further up the same valley, the limestone appears to be overlain by a great thickness of red shales and sandy clays, which persist until the Eocene Yellow Limestone is reached at a place called Ginger Hill.

The Rio Minho Watershed.

One of the most instructive Cretaceous sections in Jamaica is that at and near Logie Green. A road that winds down the valley exposes an almost continuous section. Near the top, below the covering of White Limestone, the Yellow Limestone is encountered, and yields large foraminifera (which Professor Douvillé reports as very near *Orbiculina malabarica*), decapod claws, and mollusca. The actual junction with the underlying Cretaceous limestones, however, is not visible. The sequence of the latter at Logie Green is as follows :—

	Estimated thickness in feet.
Hard yellow and blue limestone with small *Radiolites*, and sections of valves of a small *Coralliochama* . . .	20
Red shale	15
Purple shales with calcareous bands	15
Grey calcareous shales	20
Clayey nodular limestone with *Radiolites*, *Hippurites* (*Orbignya*), *Anchura* sp., and the crab *Carcineretes woolacotti*	15
Massive Rudist limestone	20
Calcareous marls with *Actaeonellae*, Rudists, etc.. . .	30
Limestones with Rudists, *Coralliochama radiolitiformis*, etc. (a small fault on the roadside)	10
Purple shales, no fossils seen	(?) 60
Massive limestone with sections of *Radiolites*, etc. . .	(?)
Grey calcareous shales	(?)
Marly partly crushed limestone full of broken Rudists, *Titanosarcolites gigantea* ; *Biradiolites jamaicensis* ; *B. semiannulosus*, etc.	50

	Estimated thickness in feet.
Brecciated limestone strongly slickensided horizontally.	(?) 50
Grey and pink calcareous shales, no fossils	(?) 40
Friable and massive limestone with *Lapeirousia nicholasi*; *Radiolites* spp., *Coralliochama radiolitiformis*; *Diploria* and other corals, etc.	20
Grey shale with Rudists, *Antillocaprina occidentalis* (very plentiful); fusiform *Actaeonellae* (like *A. coniformis* Böse), etc.	6
Massive limestone with *Coralliochama radiolitiformis*; *Titanosarcolites gigantea*, and other fossils	40
Nodular clayey limestone with the same fossils and *Praebarrettia sparcilirata*	50
(The two latter beds form a cliff or escarpment at the place that seems to bear the name Logie Green; *Praebarrettia* is found at the foot of the cliff as loose and weathered specimens on some cultivated rocky ground.)	
Grey calcareous shales with Pecten, sp. indet.	20
Red shales and coarse conglomerates	(?) 50

About 1½ miles to the east, where the road repeatedly crosses the Rodons or White Rock River, a thick limestone, apparently the lowest in the Logie Green sequence, occurs associated with coarse conglomerates. Its fossils include *Lapeirousia nicholasi*, *Titanosarcolites gigantea*, *Coralliochama*, etc., but no *Praebarrettia* was seen.

At Trout Hall, about 4 miles further east, a grey, nodular, very fossiliferous limestone occurs in the bed of the Rio Minho. It is overlain by a very considerable thickness of coarse conglomerate, and contains numerous *Biradiolites cancellatus*, *Coralliochama radiolitiformis*, and *Titanosarcolites gigantea*, all rather badly crushed, together with the crab *Carcineretes woolacotti* (its type locality), and other fossils.

I have not visited the limestones near Smithville on the southern side of the main ridge of this inlier, but Mr. G. M. Stockley, at present the Government Geologist in Jamaica, has collected some fossils there, and kindly showed them to me. They include *Biradiolites cancellatus*, *Coralliochama*, and other forms very like specimens from the Logie Green section.

Guy's Hill Area and Mount Diablo.

Sawkins maps a considerable outcrop of Cretaceous Limestone in the Parish of St. Thomas-in-the-Vale, lying to the south of and immediately adjoining a much larger area of Yellow Limestone in the Parish of St. Mary. The Cretaceous limestone here lies just to the north of and has outliers resting partly upon a large extension of granite and syenite, one of those laccolite-like intrusions which seem to have accompanied and assisted the uplift of the Island. I examined the Cretaceous exposure about 3 miles south of Guy's Hill, where it consists of a fairly massive bed of dark grey and splintery limestone, but almost the only recognizable fossils were some sections of

Actaeonellae standing out on weathered surfaces. The portion I saw was so much changed by the underlying intrusives that no fossils of any use could be collected. The Yellow Limestone to the north of this exposure yields several species of the Lutetian mollusc and echinoderm fauna, but in this area it is unusually marly and sandy in nature. In one place, near the base, I found a band of pebbly conglomerate containing a few small Oysters and some other fossils, probably an attenuated representative of the Carbonaceous Shale or Richmond Beds. Near Pear-tree Grove and Rio Magna, to the east of Guy's Hill, the Yellow Limestone also is hardened and blackened by the igneous intrusions. Near Hollymount, on the eastern slope of Mount Diablo, between Ewarton and Moneague, a dyke-like syenitic intrusion with some strips of limestone adjoining it is exposed, which Sawkins indicates as Cretaceous surrounded by White Limestone. The parts of it I saw, however, appeared to be merely changed portions of the White Limestone, darkened and hardened in the neighbourhood of the intrusive rock.

St. Ann's Great River.

An interesting series of Cretaceous beds forming a small inlier cropping out from beneath the White Limestone is exposed in the lower valley of this river, about 2 miles south-east of St. Ann's Bay. Sawkins refers to them on page 199 as the upper conglomerates of the Trappean series, and superincumbent black shales, but does not indicate the outcrop on his map. Dr. C. A. Matley has recently investigated the structure of the exposure, and has collected a series of the fossils, and kindly drew my attention to the locality. Fossils seem to occur only in the higher beds some distance up the valley. Resting upon a thick series of unfossiliferous grey shales, the sequence, as I observed it, appeared as follows :—

	Approximate thickness in feet.
Conglomerate containing numerous limestone pebbles, rather loosely consolidated. Richmond beds (?) . . .	(?)
Grey and dark shales with fossils; *Janira* cf. *quinquecostata*; *Pholadomya*; *Cyclolites*, etc.	40
Clayey limestones with fragments of Rudists . . .	10
Grey and pink nodular limestone dipping south up stream at about 60°, containing broken Rudists and complete specimens of *Biradiolites cancellatus* and *subcancellatus*, and a large specimen of *Lapierousia nicholasi* . .	12
Massive conglomerate with many igneous and a few limestone pebbles	50
Grey unfossiliferous shales	(?)

Eastern Jamaica.

It is a noticeable fact that in the Blue Mountain district the Rudist limestones are confined to the eastern and north-eastern portion. The limestones that occur over the western and south-western part seem to belong to the Carbonaceous Shale or Richmond beds. The

higher Blue Mountain peaks are mostly composed of the friable or hard and welded much folded and slickensided purple conglomerates of the so-called Trappean series, and are made up of rounded masses of andesite, pink felspar, marmorized limestone, quartz, and other rocks, with beds of consolidated ash or tuff. It is not clear to me why the Rudist Limestones should be absent from the higher regions. It may be that only the eastern portion of the Blue Mountain complex is of Upper Cretaceous age, and that the great mass of Trappean beds is of earlier date ; or that the Rudist reefs were only deposited over the eastern part of the area. The solution of the problem must await further detailed observation on the folding and other phenomena of the Blue Mountain area complex.

In limestones up the west branch of the Back River the original specimens of *Barrettia monilifera* Woodward were obtained by L. Barrett about 1860. The locality, so far as I know, has never since been visited by any geologist.

At Providence, near Port Antonio, a thick series of shales with Ammonites, Baculites, and other fossils of Campanian aspect passes gradually up into a white compact limestone, which is quarried for road material. This rock shows weathered surfaces, with many sections of branching corals, Gasteropods, including *Actaeonellae*, and traces of *Radiolites*, but no well-preserved fossils. As I hope to describe these shales and their rather extensive fauna in a future paper, mention only of this limestone is made here.

Near Mooretown, Crétaceous Limestones appear (as Sawkins indicates) as a series of more or less interrupted outcrops, following for about 2 miles the left side of the deep and very picturesque valley of the Rio Grande. Several massive grey limestone beds, reaching 40 feet in thickness occur and weather into jagged outlines, exhibiting sections of various *Radiolites*, *Titanosarcolites*, casts of Gasteropoda, and other fossils. The beds dip at more or less steep angles, and are over and underlain by a great series of conglomerates, felspathic sandstones, shales, etc., and are faulted and cut up and altered by igneous dykes at various points along the line of section. Fossils are numerous in places, but are generally broken and very poorly preserved in the dark and splintery limestones. Two or three species occur here that I have not seen elsewhere in Jamaica, but I see no reason to doubt that this limestone is approximately the same age as all the others. No echinoderms were found here.

Up the Plantain Garden River, on the south-east side of the Blue Mountain area, a section on both sides of the river exhibits several beds of semi-marmorized Cretaceous limestones, which stand nearly upright among a series of shales and Trappean conglomerates, the whole being strongly intruded by igneous dykes. The nature of the exposure seems to be very similar to that near Mooretown, on the north side of the Blue Mountain divide, and may be more or less continuous with it, but I did not find any satisfactorily preserved fossils. This is the locality where the Rudistae were first found in

Jamaica by L. Barrett in 1859, who illustrates a section of the bed here, very reminiscent of that exposed by the new road along the Rio Grande, just referred to.

List of Fossils (excluding Cœlenterata) collected in the Cretaceous Limestones of Jamaica. L = Lower part; U = Upper part of Section.	Jerusalem Mt.	Green Island.	Cambridge-Catadupa.	Great River Valley.	Logie Green.	White Rock River.	Trout Hall.	Smithville.	Guys Hill Area.	St. Ann's Great River.	Back River.	Mooretown.
FORAMINIFERA.												
Pseudorbitoides[1] *trechmanni* Douvillé		+	+	+								
ECHINOIDEA.												
Metholectypus trechmanni Hawkins		+										
Heterosalenia occidentalis ,,			+									
Botriopygus rudistarum ,,				+								
Goniopygus supremus ,,				+								
Hemiaster sp. indet.				+								
LAMELLIBRANCHIATA.												
Barrettia monilifera Woodward		+									+	
,, *multilirata* Whitfield and varieties		+										
Praebarrettia sparcilirata gen. nov. Whitf. sp.					L							
Hippurites (*Orbignya*) sp. indet.					U							
,, ,, sp. indet.				+								
Titanosarcolites gigantea gen. nov. Whitf. sp.	+		+	+	+	+	+	+	+			+
Biradiolites adhaerens Whitf. sp.			+	+	+	+	+	+				+
,, *coryi* sp. nov.			+	+								
,, *semiannulosus* sp. nov.			+	+	+							
,, *annulosus* Whitf. sp.					+							
,, *rudissimus* sp. nov.			+	+	+							
,, *rudis* Whitf. sp.					+							
,, *minhoensis* sp. nov.					+	+	+					
Biradiolites (?) *cancellatus* Whitf. sp.	+		+	+	+	+	+	+		+		?
Biradiolites (?) *subcancellatus* sp. nov.					+					+		
Biradiolites jamaicensis sp. nov.			+	+	+	+						
,, *mooretownensis* sp. nov.												+
Bournonia barretti sp. nov.			+	+	+	+						
Lapeirousia nicholasi Whitf.		+			L	+				+		
Coralliochama radiolitiformis sp. nov.			+	+	+	+	+	+				
Antilloca prina occidentalis gen. nov. Whitf. sp.		?	+	+	L	+	+					
Plagioptychus jamaicensis Whitf. sp.		+	+	+	+	+						
,, sp. indet.		+										
Ostrea arizpensis Böse, var. *jamaicensis* nov.	U											
Ostrea sp. indet. (attached to *Barrettia*)		+										
Spondylus sp. indet.		+										

[1] *Compte rendu sommaire des séances de la société géologique de France*, 18th Dec., 1922, pp. 203–4.

List of Fossils (excluding Cœlenterata) collected in the Cretaceous Limestones of Jamaica. L = Lower part; U = Upper part of Section.	Jerusalem Mt.	Green Island.	Cambridge-Catadupa.	Great River Valley.	Logie Green.	White Rock River.	Trout Hall.	Smithville.	Guys Hill Area.	St. Ann's Great River.	Back River.	Mooretown.
Chama cf. *Haueri* Zitt.		+										
Lima sp. indet.		+										
Lima cf. *azteca* Böse				+								
Cardita (*Venericardia*) cf. *subcomplanata* Archiac		+										
GASTEROPODA.												
Avellana (*Eriptycha* ?) cf. *decurtata* Zekeli		+										
Anchura sp. indet.					U							
Harpagodes sp. indet.			+	+	+	+	+	+				
Trochus cf. *plicato-granulosus* Münst.					+							
Natica (*Ampullina*) cf. *altilirata* Böse				+								
,, ,, sp. nov. indet.			+	+								
Amauropsis sp. nov. indet.				+								
Actaeonella (*Trochactaeon*) cf. *acutissima* Böse	+											
,, ,, cf. *coniformis* Böse					L							
,, ,, cf. *brevis* Böse					+			+				
Volvulina cf. *laevis* d'Orb.												+
Cerithium (*Echinobathra*) near *C. simonyi* Zekeli			+	+								
Cerithium sp. indet.							+					
Nerinaea spp.												+
Akera (?) sp. nov. indet.				+	+							
CRUSTACEA.												
Carcineretes woolacotti Withers					U		+					

The Age of the Jamaican Cretaceous Limestones.

I have already mentioned in previous papers that all the Cretaceous Limestones observed in Jamaica seem to belong approximately to one and the same high and vertically restricted horizon. Fossils, however, appear to occur in nest-like accumulations rather than in zones. My conclusions, so far as fossils are concerned, are based chiefly on a study of the mollusca and largely on the Rudistae, but the question is one that can be decided only by taking factors both of palaeontology and stratigraphy into consideration. The reasons for adhering to the belief that these limestones fall into the Campanian–Maestrichtian periods are as follows :—

1. At Providence, near Port Antonio, and again on the Cambridge–Catadupa railway section, two widely separated localities, Rudist limestones overlie shales that contain a fauna of Campanian aspect. The Cephalopods of Providence have been investigated by Dr. L. F. Spath.

2. The Rudistae, while including forms whose allies appear as

low as the Cenomanian, bear on the whole a very decidedly late aspect, and include such of the Hippuritidae as *Orbignya*,[1] *Barrettia*, and *Praebarrettia* (gen. nov.). The Radiolitidae of both the groups *Radiolites and Biradiolites* all seem to have reached the stage of evolution when the ligamentary inflexion becomes lost.[2]

3. The highest limestones that cap the hill at Jerusalem Mountain are full of an Oyster that appears to be a variety of *Ostrea arizpensis* —a shell that characterizes the Upper Senonian-Maestrichtian of Mexico.

Professor H. L. Hawkins[3] concludes from his study of the Echinoderms I collected in these limestones that a considerable vertical series of beds ranging from the Cenomanian or Turonian to the base of the Senonian is present. His evidence, however, does not seem to me at all conclusive, and I think the matter is not to be settled on such limited grounds. In view of the non-European and isolated aspect of the Rudistae, may one not venture to inquire if the same may not be the case with the echinoderms that lived in the same reef-like accumulations ?

Mr. T. H. Withers does not express any decided opinion on the age of the crab *Carcineretes woolacotti*,[4] but he informs me it is the earliest crab in which the last pair of feet are known to form swimming paddles.

The Corals are in the hands of Dr. T. W. Vaughan, of California, and a report on them is promised but has not appeared yet.

The Rudistae.

The Rudistae are the most important and also, owing to their great individual variation, the most puzzling of the mollusca of these limestones. R. P. Whitfield[5] described a number of specimens, many of them imperfect, collected by Mr. F. C. Nicholas at various places in Jamaica, the types of which are now to be seen in the cases of the American Museum of Natural History in New York. The majority of Whitfield's species are easily recognizable, but I consider his *Radiolites macroplicatus* and *Caprinella quadrangularis* to be doubtful. Some of his generic attributions seem to need revision, and three new generic names are now suggested : *Titanosarcolites*, *Antillocaprina*, and *Praebarrettia*. A common fossil that

[1] According to A. Toucas the type of the genus is *O. bioculata* of the Lower Campanian of Montagne des Cornes. The most ancient form is *O. requieni* Math. of the Lower Angoumian, and the most recent is *O. castroi* Vidal of the Lower Danian. (*Mem. Soc. Geol. France*, Tome xi, Fasc. 2, Mem. No. 30, 1903, p. 15.)

[2] Among Old World faunas, as Douvillé states, in the Radiolitidae the ligament is lost very late, disappearing in the Dordonian ; while among the Biradiolitidae it is lost in most species in the Turonian.

[3] Geol. Mag., Vol. LXI, No. 721, July, 1924, pp. 312–24; and ditto, Vol. LX, No. 707, May, 1923, pp. 199–216.

[4] *Ann. and Mag. Nat. History*, ser. ix, vol. x, pp. 534–41; and ditto, ser. ix, vol. xiii, pp. 81–93.

[5] *Bull. American Mus. Nat. History*, vol. ix, art. xii, pp. 185–96, pls. vi-xxii, 1897.

mystified me for a long time seems to be a new species of the genus *Coralliochama*. Among the Radiolitidae eight new species are described, and several yet undescribed appear to exist, but the material is yet too scanty to make specific descriptions complete. The Radiolitidae fall fairly well into the two groups of the Biradiolitidae (forms that bear two external clearly defined bands on the attached valve corresponding to the position of the mantle openings); and of the Radiolitidae (forms in which two rounded folds correspond to the mantle openings but which are in some species obscured by the general plication of the shell). All the Jamaican *Radiolites*, so far as I can observe, have lost the ligamental inflexion so that, pending further generic revision, one has the genera *Biradiolites*, *Bournonia*, *Lapeirousia*, and possibly *Tampsia*, in which to place them. Those described under *Biradiolites* fall into groups and bear certain resemblances to one another, for instance, *B. adhaerens*, *B. coryi*, and *B. semiannulosus*; another group comprises *B. rudissimus* and *B. minhoensis*. *B. cancellatus* and *B. subcancellatus* have the apex of the top valve nearly marginal, and bear curious furrows on the anterior side suggestive of *Tampsia*. *B. jamaicensis* and *B. mooretownensis* have the shape of forms of *Praeradiolites*, but have lost the primitive features. A single species each is referable to *Lapeirousia* and *Bournonia*, both genera of very late Cretaceous date, the former having two species in the uppermost chalk of the Dordogne district.

Praebarrettia gen. nov. (Pl. XXIII, Figs. 3 and 4.)

1897. *Barrettia sparcilirata* Whitfield, *Bull. American Mus. Nat. History*, vol. ix, p. 245, pls. xxxvi, xxxvii.

I suggest this generic name for Whitfield's species, of which I have collected several examples at Logie Green. It occupies an intermediate position between *Pironaea* and *Barrettia*, and the stages of evolution of the Hippuritidae may be illustrated by the genera *Vaccinites—Orbignya—Batolites—Pironaea—Praebarrettia——Barrettia*.

The lower valve is conical and slightly bent, and increases gradually in size. The radial infoldings are irregularly spaced, and are 21 to 27 in number, the position of each of these being marked on the sides by shallow furrows, the spaces between which are irregular in width and have a gently rounded surface. The surface is also marked by very fine longitudinal lines, and fine transverse growth lines and irregular shallow growth furrows. The infolded parts of the outer layer extend to the edge of the visceral chamber, and apparently those that correspond to the ligamental inflexion and the first and second pillars are indicated on the sides by rather deeper furrows than the rest. It is only at the very top near the living chamber, and then in a somewhat indefinite manner, that the infoldings take on the *Barrettia* character, and commence to divide up into a number of portions that resemble in cross-section a string of beads.

The ligamental inflexion extends well into the living chamber, and at its end is bent anteriorly nearly at a right angle; the end of the first pillar is well rounded and it is pinched at its base, the second pillar is elongated and tapers gradually. All three occupy between a half and a third of the circumference of the living chamber.

The left valve or lid is convex and cap-like, but in the best specimens I could collect is so poorly preserved and the surface is so eroded by boring organisms that I could not observe its ornamentation. None of Whitfield's specimens showed the top valve, and only a small part of the surface of the lower valve.

Praebarrettia differs from *Barrettia* in the rather deeper furrows of the outer layer corresponding to the hinge and the two mantle openings, recalling in this respect *Hippurites*, and in the row of beads structure appearing only at the summit of the lower valve. In *Barrettia* the radial infoldings are much more numerous, and the position of the pillars is not apparent on the outer surface, the ligamental inflexion is very small and short in *Barrettia monilifera* and still smaller, possibly obselete, in *B. multilirata*. *Praebarrettia* is related to *Pironaea* in the large shape and size of the ligamental inflexion, but differs in the *Barrettia*-like tendency of the radial infoldings.

Dimensions.—Length about 300 mm., diameter at top 160 mm., of living chamber 66 mm., height of top lid 46 mm.

Locality.—It occurs below the cliff at Logie Green as isolated specimens among the cultivated ground; apparently rolled before being incorporated in the bed. The interiors are completely filled with hard limestone, making development impossible.

Hippurites (*Orbignya*) spp. (Pl. XXIII, Fig. 5.)

Description.—The lower valve tapers gradually, the surface is smooth except for fine longitudinal ribs, and bears three rather shallow, broad, angular sulci corresponding to the ligamental inflexion and the two pillars. The ligamental inflexion is very short, and obtusely angular; the anterior pillar is short and rounded and slightly pinched at the base; the second pillar is rather longer with a rounded end, and is well pinched at the base. These three projections occupy more than a third and nearly a half of the circumference of the living chamber. The top valve is missing, but remains of its teeth project into the lower valve.

Dimensions.—Length of right valve 110 mm., diameter at top 34 mm.

Locality.—*Hippurites* is extremely rare in Jamaica. However I succeeded in finding six or seven poorly preserved and much bored specimens, joined together in clusters of four or five individuals, near the top of the Logie Green section. Another single example, 25 mm. in diameter, occurred in the Great River Valley opposite Catadupa, the circumference of whose lower valve seems to have about eight obtuse angulations. Better specimens will have to be

found before any specific names can be given. This genus, so familiar in the Old World, is very rare in the New, but specimens have occurred also in Mexico.

Titanosarcolites gen. nov. (Pl. XXIII, Figs. 1 and 2. Text Fig. 1.)

1897. *Caprinula gigantea* Whitfield, *Bull. American Mus. Nat. History*, vol. ix, p. 194, pls. xviii–xxii.

Among the Caprinidae and other Rudistae the shell is often traversed by a series of regular canals which generally occur in the inner portions of the shell. In exceptional cases, however, these canals may be found traversing the external layers and appear frequently as depressions of the outer layer which become deeper with the more or less rapid growth of the margin. In *Barrettia*, a specialized Hippuritid, the increase in size of the shell is accomplished by a series of deep infoldings of the outer layer which penetrate the inner layers as far as the visceral chamber. The walls of such canals are formed by invaginations of the mantle of the animal, and their physiological rôle seems to be to economize the material necessary for construction of the shell, so that it may be built up rapidly and solidly with the least expenditure of calcite. This disposition of externally formed channels is really independent of the fundamental structure of the animal, but is of great importance as a secondary character in classification.

Among European forms H. Douvillé has recorded the occurrence of large polygonal internal canals among genera belonging to the Caprinidae, such as *Polyptychus*, *Mitrocaprina*, and *Rousselia*, and the occurrence of a series of canals developed by the external layer among the Radiolitidae in the genus *Radiolitella*.[1] The large Jamaican Rudist now described belongs to a class in which a series of longitudinal tubules is developed by the outer layer of the shell. In a cross-section the larger canals are seen to be formed by a repeated growing over as the shell increases in size, in a roof-like manner of the outer ribs, the manner of junction of the edges being similar to that which forms the perforation of the shell in Terebratulidae of the *Pygope diphya* group. This process increases the size and lightness of the shell which attains in the adult stage a length of 6 or 7 feet, being so far as I know the largest Rudist mollusc recorded.

Having collected a quantity of specimens I am convinced that it belongs neither to the Caprinidae nor Caprinulidae, but is one of the Radiolitidae. One may regard it as originating from some *Radiolite* stock which found it no longer convenient to remain attached by the apex, but became recumbent on one side, by which it seems to have been lightly attached to the sea bed. The left or operculiform valve again lengthened out till it nearly equalled

[1] Sur quelques Rudistes a canaux": *Bull. Soc. Geol. Fr.*, ser. iv, t. iv, 1904, pp. 519–38.

the right or attached valve in length, the shell becoming once more a sub-equivalve one. The tendency towards the development of a dome or cap-like upper valve is met with both in Hippuritidae and Radiolitidae, but in this form it becomes extreme.

The study of this fossil becomes difficult owing to its large size and generally broken condition and frequent erosion of large parts of the test. It is often either hopelessly incorporated in the hard limestones, in many of which its peculiar tubular structure is seen, or in cases where the rock is soft it is so crushed that the walls and structure of the living chamber are badly distorted, its cellular structure having offered little resistance to the crushing forces. Whitfield illustrates some specimens collected at Logie Green, none of which show any but the smallest trace of the living chamber. His specimens consist of a fragment of a left valve with a large part of one side broken away, the apical portion of a left valve, and the broken ends of two right valves, showing the tubules and the central septate portion of the shell. He compares it with *Caprinula boissyi* D'Orb., but notes that the arrangement of the tubules differs in the Jamaican shell. He mentions among other features that the valves are curved in one plane.

Description.—Shell attaining a very large size, sub-equivalve, recumbent presumably on the anterior side, oval in section, often partly flattened on the sea bed, both valves more or less arched or bent towards one another in one plane, not spirally curved. The right valve is rather the longer and broader of the two, and reposes attached to the sea bed by the greater part of its side, its extremity is rather acutely pointed, and generally free and bent upwards from the surface of attachment.

The left valve is often more strongly curved and arched than the right and is blunt and rounded at the apex. Its anterior side is devoid of attached growths, and is more or less smoothened by having moved against the sea bed in the act of opening and closing. The junction of the valves is at right angles to the plane of curvature. The external ornamentation is very similar in both valves, and consists of a series of longitudinal rounded or angular ridges and plications between which are more or less deep folds or sulcations. The ridges are irregular but lie more or less parallel to one another, and are specially deep and sharp on the outer convex margin of the shell.

Both valves are traversed by a series of longitudinal canals, a broad belt of the openings of which surrounds the living chamber at the junction of the two valves. At their termination the larger ones are much sunken and are irregularly circular or oval in section; the smaller ones, which are developed by the inner layer, are polygonal in section and are disposed in zones around the larger ones. The two valves seem to be entirely deprived of ligamentary attachment, there is no trace of any external groove, nor of any marginal inflexion that might indicate a ligament.

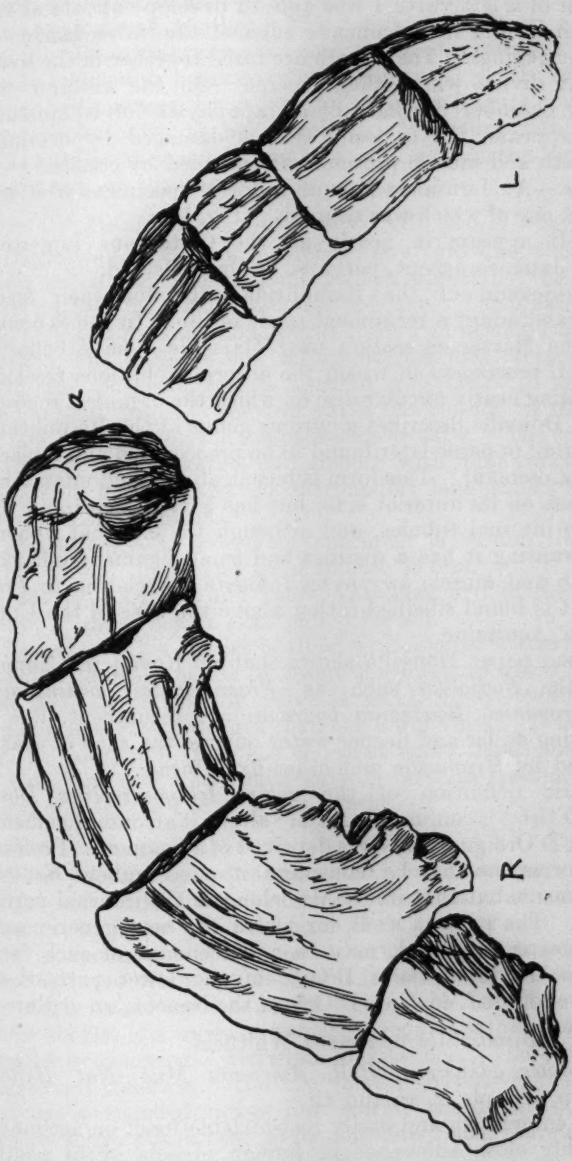


FIG. 1.—*Titanosarcolites gigantea* gen. nov. Whitfield sp. Cretaceous limestones at Jerusalem Mountain, Western Jamaica. A specimen with the valves conjoined measuring 5 ft. 4 in. in length, viewed from the side on which it lay on the sea bed. R. the right valve showing part of the living chamber at *a* and the surface of attachment and the spreading outgrowths to assist fixation. L. the left valve, the living chamber mostly crushed away, the surface smoothened by moving of the valve along the sea bed. Drawn by Miss G. M. Woodward. One-eighth natural size.

The living chamber is comparatively small, but that of the left valve is deep and the innermost part of both valves is septate.

The dentition of a left valve I was able to develop consists of two cardinal teeth at the inner concave edge of the valve inside the zone of canal openings. These teeth are fused together in the living chamber, but divide where they emerge. On the anterior side of the living chamber the base of an apophysis for a muscular attachment appears, the opposite side is damaged by crushing. The hinge teeth and muscle processes are invaded by canals.

Dimensions.—At Jerusalem Mountain I saw specimens of 5 or 6 feet in length, one of which was secured. (Fig. 1.)

Locality.—It appears in nearly all the Cretaceous Limestone exposures in Jamaica except, perhaps, at Green Island.

Affinities.—Several of the Radiolitidae abandon their apical attachments and adopt a recumbent mode of life. In the Senonian portion of the Martigues section near Marseille I have collected *Biradiolites* cf. *praeingens* in which the anterior foliations resemble a large spreading nearly circular disc on which the organism reposed. Professor H. Douvillé describes a curious genus of the Radiolitidae called *Mouretia* [1] (a name later found to be preoccupied and replaced by *Robertella* Cossman). This form is biconical, free and unattached and recumbent on its anterior side, but has a very small and thin shell with no internal tubules, and although the external siphonal sinuses are wanting it has a distinct and small ligament inflexion, and the teeth and muscle apophyses indicate its relation to *Praeradiolites*. It is found silicified rather above the base of the Upper Santonian in Aquitaine.

In the same paper Douvillé shows that at Royan in Charente nearly all the *Radiolites* such as *Praeradiolites hoeninghausi*, *Biradiolites royanus*, *Bournonia bournoni* are recumbent, due to their inhabiting stiller and deeper water outside the zone of coastal reefs occupied by *Hippurites* and other fixed forms.

The generic definition of the genus *Icthyosarcolites* Desm. (*Caprinella* D'Orb.) is confused. Zittel [2] allows it an outer ligamental furrow, while D'Orbigny [3] says it is deprived of a ligament. Professor Douvillé informs me that he considers it a recumbent *Radiolite* without ligament, but that its canals belong to the internal portion of the shell. The present shell, for which the new generic name *Titanosarcolites* is suggested, may be a descendant of such forms as *Icthyosarcolites triangularis* D'Orb. of the lower part of the Cenomanian or of the *I. doublieri* D'Orb. of the Neocomian of Europe.

Biradiolites adhaerens Whitfield.

1897. *Radiolites adhaerens*, *Bull. American Mus. Nat. History*, vol. ix, p. 188, pls. x, xi, and xii.

This is an interesting and easily recognizable fossil on account of its remarkably close adherence to foreign objects or to another

[1] "Sur un nouveau Genre de Radiolites": *Bull. Soc. Geol. France*, 4e serie, tome ii, 1902, p. 478, pl. xv, figs. 9–12.

[2] *Handb. der Palaeontologie*, abt. i, band ii, p. 79.

[3] *Palaeontologie Francaise*, tome iv, 1847, p. 189.

specimen of its kind, two or three individuals sometimes growing close against one another. The bands of the lower valve are well defined, the anterior one is smooth and gently rounded, the posterior one is wider and bears four or five parallel gently rounded longitudinal ribs crossed by growth foliations, a feature seen also on the two species next to be described. It occurs rather plentifully at Logie Green, around Catadupa, and also in the limestones near Mooretown on the Rio Grande.

Biradiolites coryi sp. nov. (Pl. XXV, Fig. 5.)

Description.—Shell of moderate size, growing singly with the lower valve attached to some convex object by the greater part of its anterior side which becomes concave. The foliations are small and thin and directed downwards; the two siphonal bands are well marked, the anterior one rather narrow and crossed by growth lines, the posterior one is broader and bears in addition faint longitudinal ridges. The top valve fits closely on the lower one, its laminae covering the top of the lower valve. The central portion is conical, very elevated, and smooth with faint concentric growth lines, and both it and the surrounding laminations bear rounded low radial undulations.

Dimensions.—A good-sized specimen is 94 mm. high, the top valve 54 mm. high, and its diameter 65 mm.

Locality.—Around and below Catadupa and in the Great River Valley; about seven examples collected.

Remarks.—This species is allied to *Radiolites adhaerens* Whitfield, but does not clasp nearly so closely the object to which it is attached, and the cap of the top valve is much more elevated, attaining sometimes a greater length than the lower valve. It is named after Mr. R. Cory, jun., who has collected many fossils round his home at Catadupa and who kindly gave me several specimens, including the first example I saw of this species.

Biradiolites semiannulosus sp. nov. (Pl. XXV, Figs. 6 and 7.)

Description.—Shell of moderate size, individuals varying much in height and width, the lower valve turbinate or sub-cylindrical; attached by about half the length of its anterior side. The anterior band is seen in some specimens and is narrow and smooth, the second band is more often apparent and is faintly ribbed longitudinally, but both bands are frequently covered by the growth foliations. These consist of a series of numerous regular rather closely arranged parallel or concentric varix-like annulations. There is no trace of a ligament inflexion. The top valve nearly covers the lower one, and has a rounded rather low central raised portion surrounded by thin foliae which bear 20 or more low radial undulations.

Dimensions.—Height up to 106 mm., diameter up to 50 mm.

Locality.—Logie Green, Catadupa, etc.

Remarks.—This species may be identical with *Radiolites annulosus* Whitfield; the latter species is, however, founded on one specimen

with an eroded upper valve, and seems to have a more turbinate lower valve and more regular annulations. It is evidently related to *B. adhaerens* Whitfield and *B. coryi* sp. nov., but differs in its slight adherence to foreign objects and its conspicuous annulations.

Biradiolites rudissimus sp. nov. (Pl. XXVI, Figs. 4, 4*a*, and 5.)

Description.—Shell of moderate size; free, or growing in clusters lightly attached; very irregular in form and shape, the lower valve either conical or low and sphaerulite-like in shape. The foliations are very irregular and wavy, and are thin or massive and more or less spreading. There is no trace of a ligament inflexion; the anterior siphonal band is indicated by an irregular angular depression, sometimes with an indefinite raised ridge passing up it; the posterior mantle opening is marked by a broad, distinctly sunken, flat, or slightly convex band, crossed by coarse growth lines. The top valve does not quite cover the lower valve, it is thin and more or less convex, with a subcentral apex decorated with irregular rounded ribs radiating from the apex, but is frequently raised and obscured by coralline and other growths.

Dimensions.—Length up to 105 mm., diameter at top up to 109 mm.

Locality.—Logie Green section; railway line between Cambridge and Catadupa; the Great River Valley, etc.

Remarks.—This fossil, of which I have about sixteen specimens, seems, as regards the foliation and banding of the lower valve, to be related to the single specimen which Whitfield figures as *Radiolites rudis* on pl. xi, fig. 4, of his paper, but does not seem to be identical. It is the most irregularly shaped and clumsily grown *Radiolite* that I have seen.

Biradiolites minhoensis sp. nov. (Pl. XXVI, Figs. 1 and 1*a*.)

Description.—Shell of moderate size; the lower valve conical with concave sides; the laminae are strong and irregular, but not very spreading, and are all directed upwards and outwards. The anterior siphonal band is obscure, and is marked by a rough more or less deep depression, the second band is flat or rather concave, broad, well defined, and sunken, and crossed by rough growth lines. The top valve has a sub-central apex, is thin, sunken, slightly concave, and smooth, sometimes with low undulating radial ribs and fine growth foliations near the edges. The portion extending from the region of the posterior band of the lower valve to the apex is slightly flattened and sunken, and the top valve measures considerably less than the diameter of the top of the lower valve.

Dimensions.—Height up to 95 mm., diameter of lower valve 65 mm., ditto of upper valve 40 mm.

Locality.—Logie Green; and Trout Hall in the Rio Minho Valley. It is a scarce fossil.

Remarks.—The siphonal bands in this form resemble those of

B. rudissimus, but it differs in its conical form and in the concavity of the top valve.

Biradiolites cancellatus Whitfield sp. (Pl. XXIV, Fig. 4.)

1897. *Radiolites cancellatus, Bull. American Mus. Nat. History*, vol. ix, p. 190, pls. xii and xiii.

This form, which is well figured by Whitfield, is of moderate size, grows free or lightly attached in clusters of three or four individuals. The anterior side of the lower valve is more or less flattened, and bears one or often two narrow, shallow, longitudinal grooves, which do not correspond to the apex of the top valve, and do not extend to the region of the living chamber, but seem to be confined to the cellular layer. Cross-sections show no trace of ligament inflexion. The rounded posterior and lateral sides bear six or seven prominent folds and sulci, by which the position of the mantle openings is quite obscured. The top valve is well raised, and the apex is situated well towards the anterior margin ; it nearly covers the lower valve, and has the margin angulated to correspond with it, and bears numerous well-marked wire-like growth foliae.

Locality.—It is common at Trout Hill and St. Ann's Great River, but is rare in the Logie Green section.

Biradiolites subcancellatus sp. nov. (Pl. XXVI, Fig. 3.)

Description.—Shell of moderate size, growing singly or a few lightly attached together ; stumpy, increasing rapidly in size. The lower valve bears strong upwardly directed growth foliae. The side near which the apex of the top valve lies is flattened or rather concave, and has a well-marked longitudinal groove or inflexion ; the posterior and lateral margins of the valve are rounded and bear six or seven prominent angular ridges with deep angular grooves between them. The top valve is slightly convex, and covers the lower one, the apex is well towards the anterior margin, and the margins are angulated to correspond with the lower valve, and growth foliations are well marked. There is no trace of ligament inflexion, and the position of the mantle openings is obscured by the folding.

Dimensions.—Height 52 mm., diameter at top 67 mm. by 46 mm.

Locality.—It occurs at Logie Green, and St. Ann's Great River, but seems to be rare.

Remarks.—This form is allied to, but shorter and more stumpy than, *B. cancellatus*, and the ribs of the outer side are much more prominent and angulated, and there is only one groove on the anterior side of the lower valve. Both these species may have some connexion with the genus *Tampsia*, recently established by L. W. Stephenson,[1] in the curious longitudinal anterior grooves that apparently do not correspond with any internal structure of the animal and seem to extend only to the middle cellular layer. They also show in polished sections the concentric growth lines enclosing

[1] "Some Upper Cretaceous Shells of the Rudist group from Tamaulipas, Mexico" : *Proc. U.S. Nat. Museum*, vol. lxi, art. i, 1922, p. 4, pls. i–viii.

layers of small irregularly sized cells which are characteristic of *Tampsia*. Both *B. cancellatus* and *subcancellatus* are allied in shape-character to *Biradiolites potosianus* [1] Böse, of the Lower Senonian (*Coralliochama G.-Boehmi* bed) of Mexico and all including *Tampsia* are deprived of ligamental inflexion. The attribution of these two Jamaican forms to the genus *Biradiolites* is questionable since the mantle openings are obliterated by the external folding of the shell.

Biradiolites jamaicensis sp. nov. (Pl. XXIV, Figs. 5, 5*a*, 6, 6*a*, 7.)

Description.—Shell elongated, tapering gradually, more or less curved to the right or left, growing generally in clusters of many individuals loosely joined together by their whole length. The lower valve bears eight to eleven angular longitudinal ridges, separated by angular furrows which are irregular in depth, some specimens being more deeply plicated than others. One side which seems to correspond with the position of the posterior mantle opening, and is generally rather flat or concave bears two small low but persistent folds of equal height with a small round-bottomed groove between them. Some specimens are nearly free of growth furrows and foliations, but in others these are rather strongly developed, especially towards the upper part of the lower valve. The top valve in some individuals nearly covers the lower valve, in others it fits well into it, and has angular marginal projections to correspond with the folds of the lower valve. It is more or less concave, with a sub-central apex and bears fine concentric growth laminations. There is no trace of a ligamental inflexion, and the position of the anterior mantle opening is lost in the folding of the lower valve. The cells of the inner layer are coarse and irregular in section.

Dimensions.—Length up to 140 mm., diameter at top up to 42 mm.

Locality.—Logie Green; the Great River Valley; around Catadupa. About fifty specimens collected.

Remarks.—This species has the general elongated shape and plication of *Praeradiolites davidsoni* [2] Hill, of the Albian of Texas, but does not exhibit the primitive characters of that form and does not seem to be, except as regards outward shape, connected with it.

Biradiolites mooretownensis sp. nov. (Pl. XXV, Fig. 8.)

Description.—Shell small, elongated, tapering gradually, gently curved, growing in clusters of many individuals of various sizes. The lower valve bears eleven or twelve longitudinal unequal irregularly spaced ridges, separated by shallow sulci and crossed by inconspicuous growth interruptions and fine growth lines. The position of the second mantle opening may be indicated by a pair of small ridges that pass up one rather flattened side of the shell. No trace of a ligament inflexion is to be seen, though, owing to the

[1] *Boletin Instituto Geologico de Mexico*, Num. 24, 1906, p. 60, pls. v, xi, and xii.
[2] H. Douvillé, *Bull. Soc. Géol. France*, 4e serie, t. ii, 1902, pl. xv, figs. 6, 7.

poor state of the fossils at this locality, one cannot be quite sure of this. The upper valve is concave and well sunken, has a sub-central apex, and bears fine concentric growth laminae.

Dimensions.—Length up to 56 mm., diameter at top 15 mm., ditto of top valve 11 mm.

Locality.—The limestones on the Rio Grande near Mooretown are the only beds in which I have seen this small *Radiolite*, which affects the same habit of growth in clusters as the larger species, *B. jamaicensis*.

Bournonia barretti sp. nov. (P. XXVI, Figs. 2 and 2*a*.)

Description.—Shell of moderate size attached by the apex and a portion of one side, growing apparently singly. The lower valve is gently curved at the apex, thick, and stumpy, the height rather more than the diameter at the top. It bears about fifteen strong, angular, longitudinal plications, which are cut by strong growth furrows, the blunt roughened projections so formed projecting upwards and outwards. The living chamber is oval or kidney-shaped in outline, and shows no trace of ligamental inflexion and all trace of bands corresponding to mantle openings is lost in the plication of the shell. The foliations round the edge are generally longer and more spreading on the side where the attachment was than round the rest of the margin. The upper valve is rather sunken, but slightly convex with a sub-central rather raised apex, and is marked with growth foliations and marginal projections fitting into the plications of the lower valve, which it nearly covers.

Dimensions.—The largest example is 91 mm. high, diameter at top 70 mm., ditto of living chamber 33 mm. by 24 mm.

Locality.—Logie Green; the Great River Valley; and on the railway line between Cambridge and Catadupa. Seven specimens.

Remarks.—This is a scarce but easily recognizable form, unfortunately often crushed. Whitfield's figure of *Radiolites macroplicatus* (pl. xii, fig. 2) may represent it, but his other figure (pl. xiii, fig. 8) certainly does not, and looks to me like a young example of *Coralliochama*. I name it after Mr. L. Barrett, the discoverer of Cretaceous fossils in Jamaica, who lost his life there when his work had scarcely commenced.

Lapeirousia nicholasi Whitfield.

1897. *Bull. American Mus. Nat. Hist.*, vol. ix, p. 186, pls. vi–ix.

This is a very large and massive *Radiolite*, sometimes 2 feet in height and over a foot in diameter. I have never found a specimen well enough preserved to show if the upper valve bears the two marginal oscules or perforations corresponding to false pillars that mark the mantle openings of the lower valve, which would definitely refer it to the genus *Lapeirousia*. It is an easily recognizable fossil in the field, though often very much broken up. It occurs at Green Island in the *Barrettia* bed; at Logie Green in the lower portion of the section with *Praebarrettia sparcilirata*; and at St. Ann's

Great River in the limestones high up in the section, where Dr. C. A. Matley found a large specimen of it.

Coralliochama radiolitiformis sp. nov. (Pl. XXIV, Figs. 1, 2, 2*a*, and 3.)

Description.—Shell growing singly attaining a considerable size, the right valve attached by or near to its apex, thick, rather stumpy, or sub-pyramidal in shape, decorated with about twenty very irregular broad or narrow, more or less convex, longitudinal ribs, separated from one another by shallow or deep angular furrows. The ribs are frequently interrupted by transverse growth furrows, and produced into thumb-like outward or downwardly directed prolongations, which, however, tend to disappear as the valve increases in height. The surface is also decorated with numerous very fine longitudinal ridges and sharp transverse growth lines. The lower valve is made up of a very thin outer layer, a thick inner coarsely cellular portion, the cells irregular and polygonal in section, and an internal septate portion. The outside of the lower valve shows no trace of a ligament groove. The upper or left valve almost covers the lower one when not eroded, and bears four or five broad faint radiating ridges ; it is broadly convex and bluntly pointed in young shells, but becomes large and strongly arched in older specimens which sometimes develop a broad, smooth, concave, false area above the hinge region. The margins of the upper valve are produced into rounded extensions corresponding with the ribs of the lower valve. The outer layer is dark-coloured and smooth, and is decorated with fine microscopic concentric growth-lines ; the inner layer has a central prismatic portion, the outer part of which passes into numerous thin, close-set, radiating, vertical plates or septa, which towards the outer margin divide into twos and threes, their edges abutting against the outer layer, as in the genus *Plagioptychus*. The innermost portion of the upper valve is septate.

I have not been able to observe the interior of the lower valve, and that of the upper one is not easy to develop. It has two large cardinal teeth lying close together, the posterior one specially massive, and both of them invaded by the cellular structure of the inner part of the valve. It is not clear if there was a septum in the visceral chamber, but there are traces of accessory cavities near the margin behind the posterior tooth as in *Plagioptychus*.

Dimensions.—The largest example collected (Fig. 1) is about 206 mm. long and 117 mm. broad ; the top valve is generally about half the height of the lower one.

Locality.—At Logie Green it occurs throughout the section, the larger specimens low down, but becoming dwarfed as one ascends ; and is common in other localities.

Remarks.—This fossil agrees fairly well with the generic definition of *Coralliochama orcutti*[1] White, of the Cretaceous of Lower

[1] Chas. A. White, *Bull. U.S. Geological Survey*, vol. iii, 1885, p. 10, pls. i–iv.

California, except that the lower valve has no trace of a ligament groove. Another species, *C. G.-Bochmi*[1] Böse; from the Lower Senonian of Mexico differs from the present form in the absence of projections on the lower valve and the presence of a longitudinal ligament furrow. The lower valve of the Jamaican shell has a very deceptive *Radiolite*-like aspect if the top valve is missing or in young specimens where it is low or cap-like.

Antillocaprina gen. nov. (Pl. XXV, Figs. 1, 2, and 3.)

1897. *Caprinella occidentalis* Whitfield. *Bull. American Mus. Nat. History*, vol. ix, p. 193, pls. xvi and xvii.

Whitfield gives seven figures of this shell, which show its external features, the irregularly curved and elongated, often straggling or corkscrew-like right valve, and the more or less closely rolled left valve, turned either to the right or left. Either valve may be the larger, but it is generally the right one. It appears to have been a free or lightly attached organism. His generic attribution seems to me erroneous, and I propose to place it under a new genus, *Antillocaprina*. The outer layer of the shell is very thin; the innermost porcellanous layer is confined to a lining of the visceral chamber; the whole intermediate portion of both valves is occupied by a tightly packed mass of small, with occasionally a few large, tubules, which are oval or polygonal in section, and which invade the hinge teeth and the area of the muscle attachments. The structure of the living chamber is quite unlike that of *Caprina*, *Plagioptychus*, or *Coralliochama*, and recalls that of *Monopleura*.[2] The left valve has two sharp and bent cardinal teeth, the posterior one the larger, the socket of the opposing tooth lying between them; there is no septum in the living chamber, nor any accessory cavities behind the posterior tooth as in *Plagioptychus*, *Caprotina*, etc.

Dimensions.—The two valves attain a length of 200 mm. or more.

Locality.—This fossil occurs plentifully rather low in the Logie Green section; also in a bed of yellow marly limestone on the north slope of the Great River Valley, below Catadupa, but specimens are there generally crushed.

Plagioptychus jamaicensis, Whitfield. (Pl. XXV, Fig. 4.)

1897. *Caprina jamaicensis. Bull. American Mus. Nat. Hist.*, vol. ix, p. 192, pl. xiii, figs. 1 and 2, and pl. xv.

This fossil has all the essential structure of a *Plagioptychus*; the interior of a top valve I developed shows a pointed anterior cardinal tooth supporting a septum which projects down into the visceral cavity; a socket for the opposing tooth, and an elongated posterior-tooth with behind it three marginal accessory cavities, whose use is uncertain. All my specimens are small, up to 55 mm.

[1] "La fauna de moluscos del Senoniano de Cardenas": *Bol. Instituto geologico de Mexico*, Num. 24, 1906, p. 54, pls. vi, xi–xiii, and xv.

[2] Cf. *Monopleura forojuliensis* Pirona. *Mem. del R. Instituto Veneto*, vol. xxii, 1884, p. 697, pl. vii, figs. 5–14.

across the valves, and are closely attached by the anterior side of the right valve. I have not seen one of the large size of Whitfield's figures on pl. xv. It occurs at Logie Green; in the Great River Valley, and elsewhere.

The top valve of another species of *Plagioptychus* occurred in the *Barrettia* bed at Green Island; it is 80 mm. long, 88 mm. wide, and 54 mm. high, and has a rapidly tapering and rather anteriorly directed incurved beak.

Ostrea arizpensis Böse; var. *jamaicensis* nov. (Pl. XXV, Fig. 9.)

The highest limestones at Jerusalem Mountain contain numerous Oysters associated with occasional *Radiolites*, generally so firmly fixed in the rock that they break across or through the shell. The Oysters seem to belong to one species, but vary much in size and age, the larger ones becoming much inflated towards the lower margin of the valves. Two or three better preserved examples I collected resemble the Mexican form[1] in the sub-equality of the valves, curvature of outline, and the false area of the hind margin, and prominence and smoothness of the umbones. The Jamaican specimens differ, however, in the fact that the ribs dichotomize towards the lower margin, and in the swelling of the valves in older specimens. This Alectryonia or Lopha-like oyster may be a variety or a derivative of the Mexican species which characterizes the upper part of the Upper Senonian (Campanian–Maestrichtian), and overlies a bed with *Exogyra costata* Say, *Inoceramus crippsi* Goldf., and other fossils.

EXPLANATION OF PLATES XXII–VI.

FIG.

PLATE XXII.

1.—The Great River Valley opposite Catadupa. In the centre Rudist Limestone cropping out among Trappean Shales. In the distance hills of White Limestone (Oligocene, etc.), which surround the Cretaceous inlier in an amphitheatre-like manner.

2.—Locality near the last. Outcrop of Rudist Limestones full of *Radiolites* and other fossils, dipping towards the lower left corner of the picture.

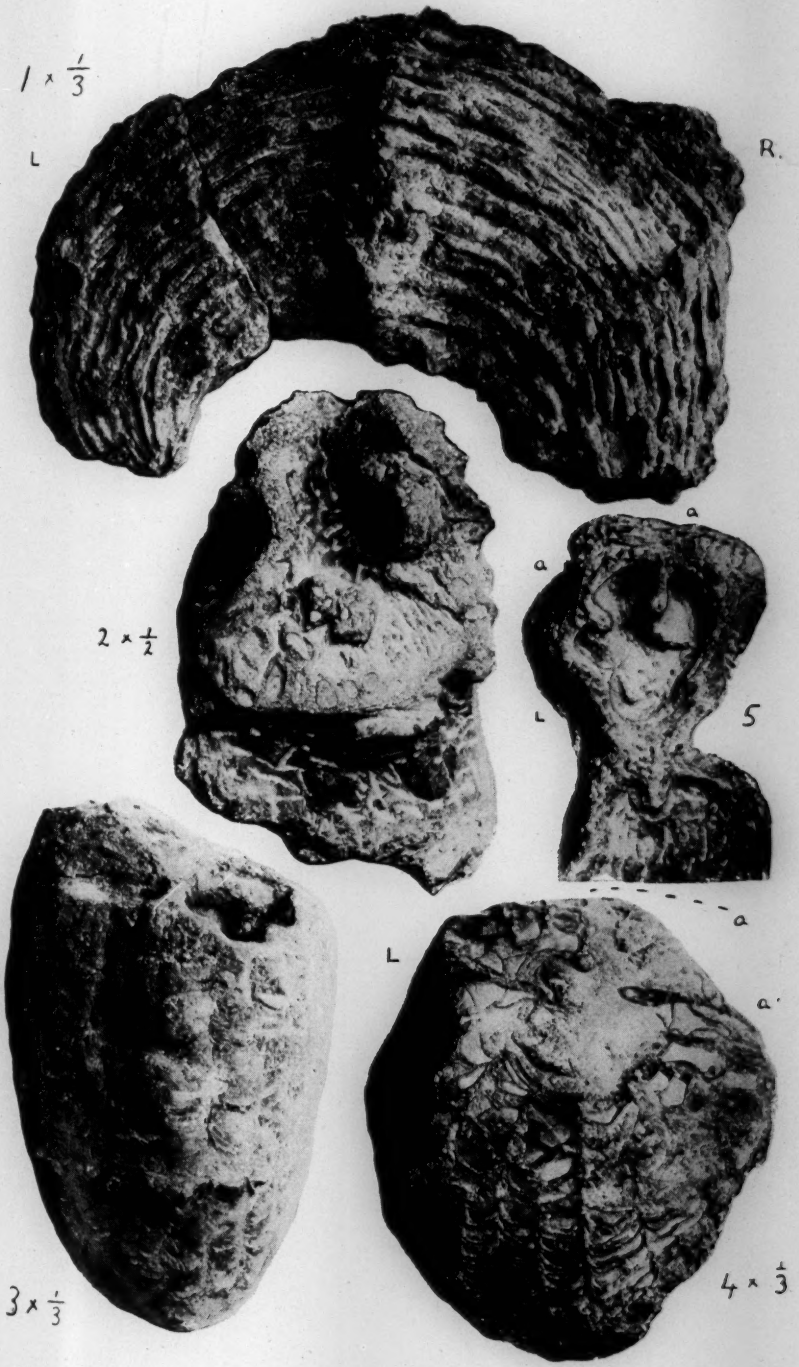
3.—Green Island or Haughton Hall. Outcrop of the *Barrettia* Limestone. In front a specimen of *Barrettia monilifera* lies split lengthwise, nearly three feet long; behind it are cross-sections of other *Barrettiae* and of *Lapeirousia nicholasi*.

PLATE XXIII.

1.—*Titanosarcolites gigantea* gen. nov. Whitf. sp. Great River Valley below Catadupa. Example with valves conjoined. R right, L left valve. About one-third natural size.

2.—Same species, same locality. A left valve, the interior cleaned out. At the lower edge large tubules surrounded by small ones are seen, and above these two cardinal teeth fused together, the ends broken off. To the right of the living chamber is the base of a process for muscle attachment; the wall of the opposite side has been crushed in. About half natural size.

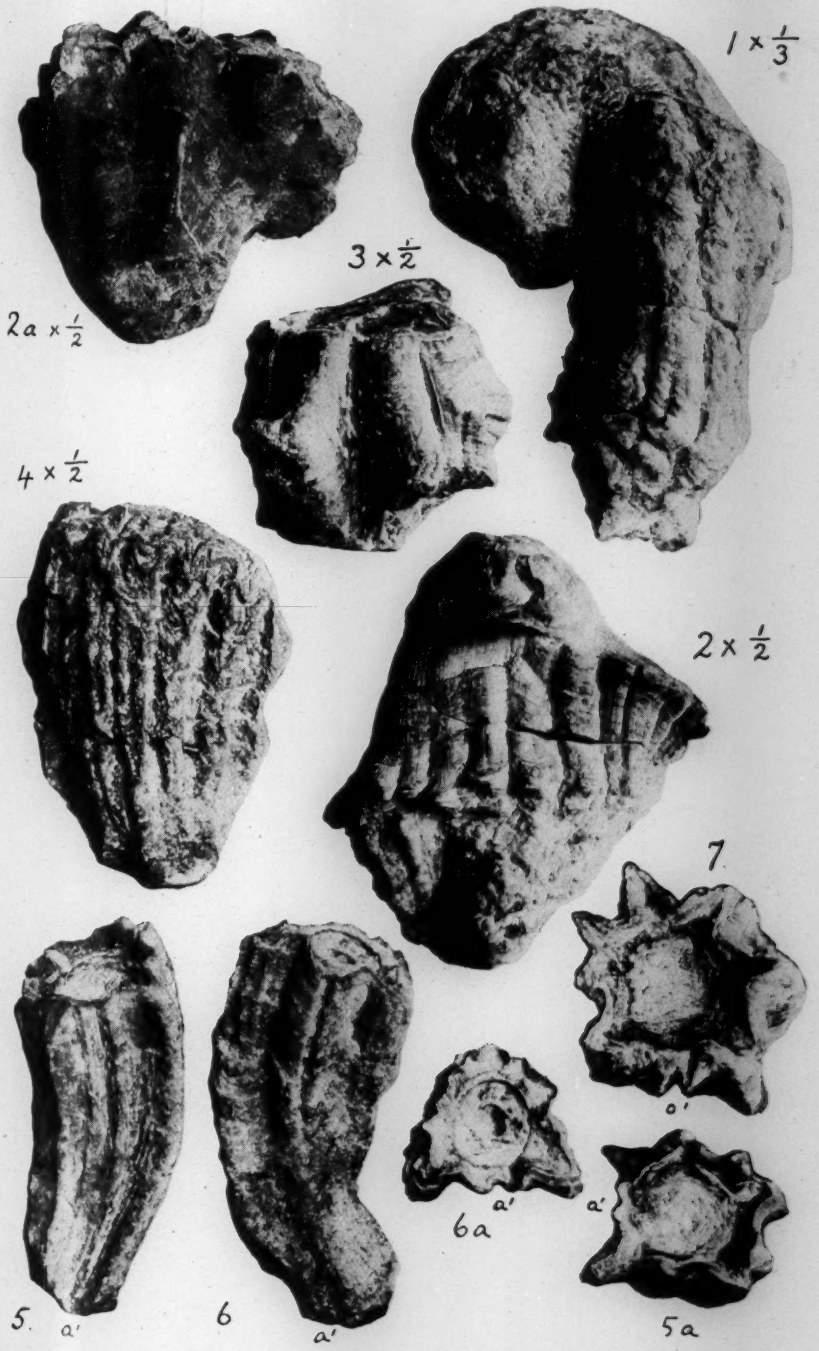
[1] E. Böse, "Algunas Faunas del Cretacico Superior de Coahuila": *Instituto Geologico de Mexico*, num. 30, 1913, p. 48, pl. viii, figs. 7–17.



C. T. T. *photo.*

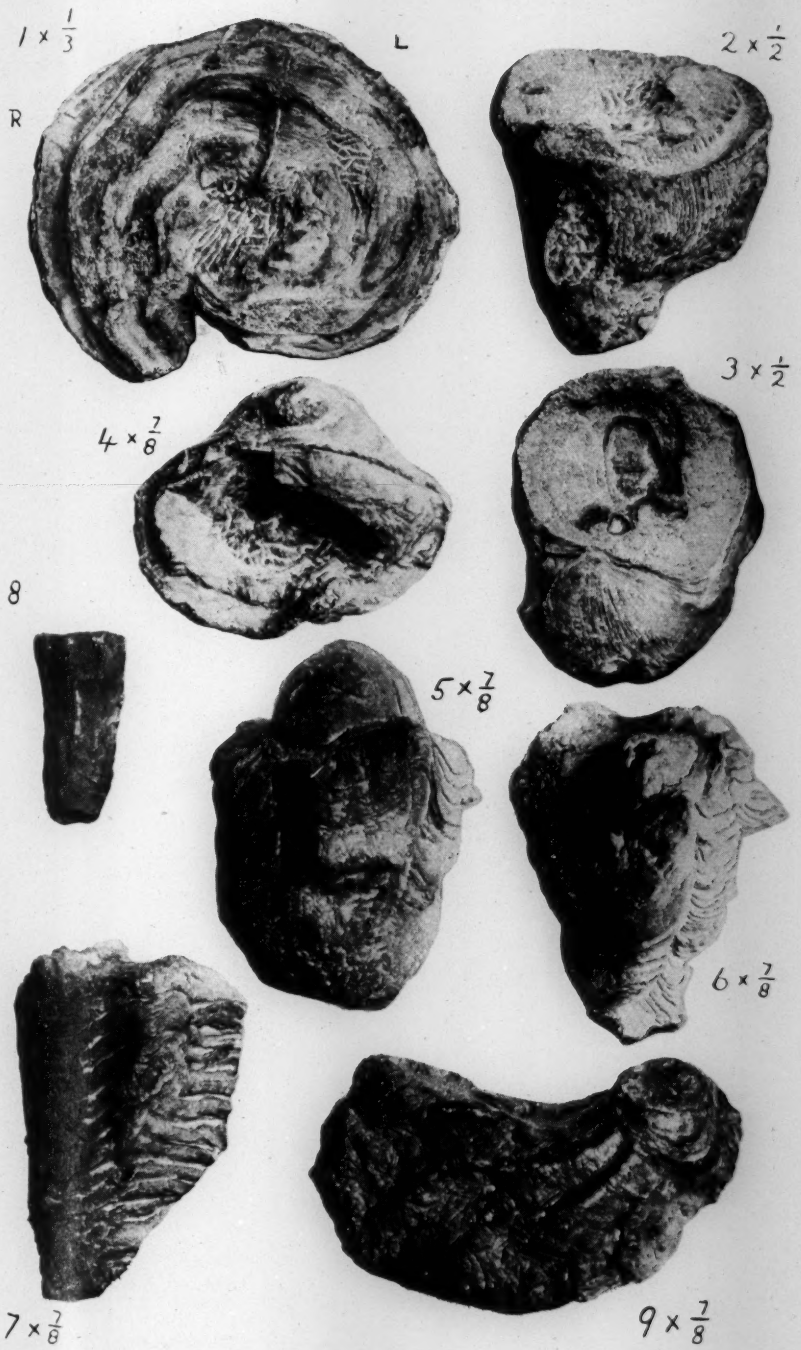
RUDISTAE FROM JAMAICA.

Titanosarcolites gen. nov., *Praebarrettia* gen. nov., and *Orbignya*.



C. T. T. photo.

CORALLIOCHAMA AND *BIRADIOLITES* FROM JAMAICA.



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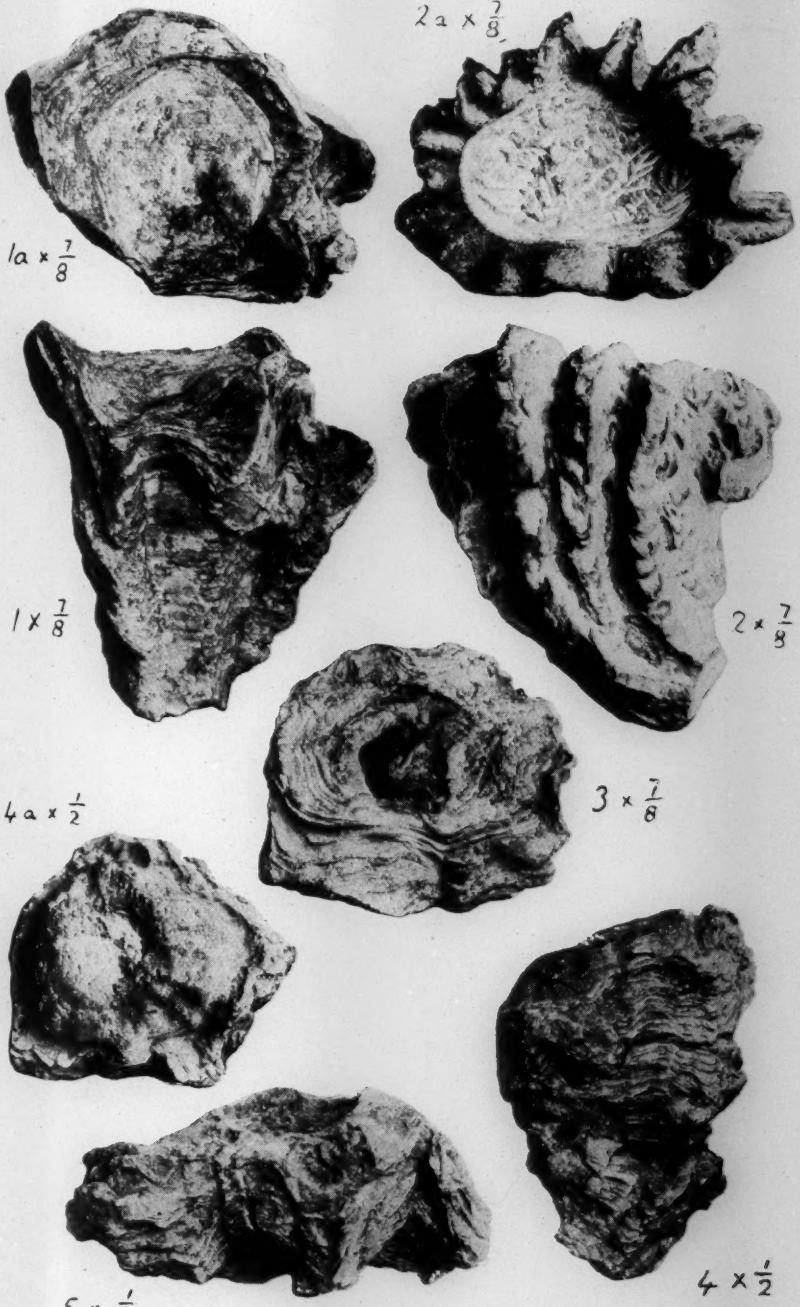
RUDISTAE AND *OSTREA* FROM JAMAICA.



C. T. T. photo.

RADIOLITIDAE FROM JAMAICA.

FIG.

3.—*Praebarrettia sparcilirata* gen. nov. Whitf. sp. Lower part of the Logie Green section. A lower valve with the surface preserved and remains of the conical top valve in situ. Rather under a third natural size.

4.—Same species, same locality. Top view of a lower valve the surface eroded away and the living chamber filled with limestone, showing the ligamental inflexion (L) and the first and second pillars (a and a^1). Rather under a third natural size.

5.—*Hippurites* (*Orbignya*) sp. indet. Upper part of the Logie Green section. Top view of two examples conjoined, the living chamber partly cleaned out, showing ligamental inflexion (L) and first and second pillars (a and a^1). About natural size.

PLATE XXIV.

1.—*Coralliochama radiolitiformis*, sp. nov. White Rock River below Logie Green. An aged complete specimen, the surface of the top valve rather eroded. About a third natural size.

2 and 2*a*.—Same species. Logie Green section. A young specimen, the top valve well arched and the outler layer well preserved. An anterior view of the two valves and a top view of the lid. About half natural size.

3.—Same species, same locality. A very young specimen, the top valve cap-like and low, and not yet arched over the hinge area. Side view, about half natural size.

4.—*Biradiolites* (?) *cancellatus* Whitf. sp. St. Ann's Great River Valley. Posterior and lateral view of a specimen with both valves conjoined. About half natural size.

5 and 5*a*.—*Biradiolites jamaicensis* sp. nov. Great River Valley opposite Catadupa. Side and top view of a specimen with top valve in place. About natural size.

6 and 6*a*.—Same species, same locaiity. Side and top view of a specimen, the top valve missing. About natural size.

7.—Same species. Logie Green section. Top view of a strongly angulated specimen, the upper valve in place. About natural size. The bands and groove corresponding to the mantle opening is indicated in these figures by a^1.

PLATE XXV.

1.—*Antillocaprina occidentalis* gen. nov. Whitf. sp. Great River Valley below Catadupa. Anterior view of a rather crushed example with valves conjoined, R right, L left valve. About a third natural size.

2.—Same species, same locality. A right valve of a young specimen, the interior partly cleaned out, showing the muscle scars, etc. About half natural size.

3.—Same species. Lower part of the Logie Green section. A young left valve, the interior cleaned out, showing the visceral chamber, posterior tooth, socket for opposing tooth, and base of the anterior tooth which is broken off, and two muscle scars, etc. About half natural size.

4.—*Plagioptychus jamaicensis* Whitf. sp. Logie Green. A left valve with the interior cleaned out, showing pointed anterior tooth supporting a septum, elongated posterior tooth with accesssory cavities behind it, etc. Slightly reduced.

5.—*Biradiolites coryi* sp. nov. Near Catadupa. Specimen with valves conjoined, showing the siphonal bands. Slightly reduced.

6.—*Biradiolites semiannulosus* sp. nov. Logie Green. Specimen with valves conjoined, showing the siphonal bands. Slightly reduced.

7.—Same species, same locality. Lateral view of a specimen, the top valve partly eroded away, showing the annulations and attachment area of lower valve. Slightly reduced.

8.—*Biradiolites mooretownensis* sp. nov. Limestones on the Rio Grande, near Mooretown. Side view of a lower valve, the top valve in place but not seen. Slightly reduced.

9.—*Ostrea* (*Alectryonia*) *arizpensis* Böse, var. *jamaicensis* nov. Highest limestones at Jerusalem Mt. Slightly reduced.

PLATE XXVI.

FIG.

1 and 1*a*.—*Biradiolites minhoensis* sp. nov. Logie Green section. Side view showing siphonal bands and top view of a specimen with valves conjoined. Slightly reduced.

2 and 2*a*.—*Bournonia barretti* sp. nov. Great River Valley opposite Catadupa. Side and top view of a specimen with the upper valve missing. Slightly reduced.

3.—*Biradiolites sub-cancellatus*, sp. nov. Logie Green section. Side and partly top view of a specimen with valves conjoined, but the lower part missing, showing the furrow on the anterior side of the lower valve. Slightly reduced.

4 and 4*a*.—*Biradiolites rudissimus* sp. nov. Railway line between Cambridge and Catadupa. Side view showing the bands and top view of a specimen with the valves conjoined. One-half natural size.

5.—Same species, same locality. Side view of a squat, sphaerulite-like specimen showing the bands, the top valve missing. One-half natural size.

Dimitobelidae—a new family of Cretaceous Belemnites.

By F. W. WHITEHOUSE, M.Sc., St. John's College, Cambridge.

THE Cretaceous beds of the Southern Hemisphere contain a peculiar group of Belemnites which differs from all contemporary families previously described in that a ventral groove is never present. Hitherto, the individual species have been recorded either under the generalized name of *Belemnites* or else as members of such pre-existing genera as *Actinocamax*. In 1917, however, the independence of the group was recognized by Woods,[1] who remarked that " It is probable that the group of species to which *B. lindsayi* belongs should be regarded as a special section of *Belemnites* ".

The species known at present may be grouped into four genera, constituting a family of *cylindrical and clavate belemnites provided with lateral grooves on the anterior portion of the guard, but devoid of antero-ventral or apical grooves.*

Genus PERATOBELUS nov.

Definition.—Guard cylindrical or clavate with ventro-lateral grooves only. These grooves extend for about half the length of the guard. Alveolus normal.

Genotype.—*Belemnites oxys* Tenison-Woods (Fig. 1, *a*, *b*).

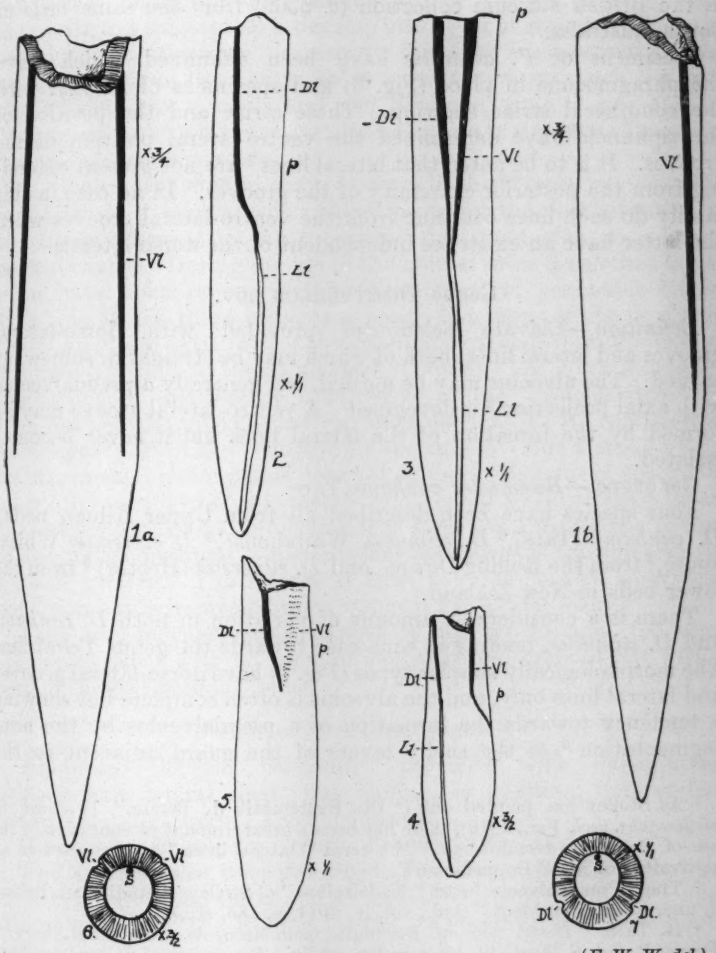
Two species only have been described, *P. oxys* (Ten.-Woods)[2] and *P. australis* (Phill).,[3] from the basal beds (Up. Aptian)[4] of the " Rolling

[1] H. Woods, " The Cret. Faunas of the N.E. por. of S. Island of New Zealand " : *N.Z. Geol Surv. Pal. Bull.*, iv, 1917, p. 37.

[2] See J. E. Tenison-Woods, " On some Mesozoic Foss. from Cent. Aust.," *Proc. Linn. Soc. N.S.W.*, 1883, viii, 2, pp. 235–42, pls. 1–2 ; also R. Etheridge, Jr., " Mon. Cret. Invert. Fauna, N.S. Wales " : *Mem. Geol. Surv. N.S.W. Pal.*, No. 11, p. 48, pls. vi–viii.

[3] J. Phillips, " Australian Belemnites " : *Q.J.G.S.*, xxvi, 1870, p. 258, pl. xvi, figs. 1, 2, 6, only. Tate's name *B. eremos* (*Rep. Aust. Ass. Adv. Sci.*, 1888, i, p. 229) was proposed for Phillips' *B. cf. paxillosus* Schloth. (Phillips, loc. cit., fig. 6), which is merely the young stage of *B. australis* ; so that the name *eremos* must be abandoned.

[4] The evidence for the age and divisions of the Rolling Downs will be published elsewhere. It may be stated, however, that the lower (Up. Aptian) series contains the Ammonite genera *Aconeceras, Sanmartinoceras, Tropaeum*, etc.



(*F. W. W. del.*)

FIGS. 1 *a*, *b*. *Peratobelus oxys* (Ten.-Woods); 2, 3, 7, *Dimitobelus canhami* (Tate) (2 simple form, 3 advanced form); 4, *Tetrabelus seclusus* (Blanf.); 5, *Cheirobelus lindsayi* (Hector); 6, *Peratobelus australis* (Phill.). 1*a* ventral view; 1*b*–5 lateral views; 6, 7 cross-sections in the alveolar regions; *Dl.* Dorso-lateral groove; *Vl.* ventro-lateral groove; *Ll.* lateral lines; *p.* base of alveolus (or pseudalveolus); *S.* siphuncle. The positions only and not the relative strengths of the grooves are indicated (except in Fig. 5 where the rudimentary nature of *Vl.* is indicated). Fig. 1 after Etheridge.

Downs" formation of Eastern Australia. Both species are cylindrical forms (*P. oxys* modified by an apical acumination); but an unnamed third species of a clavate form is represented by a specimen

in the British Museum collection (*c.* 5309) from the same beds in South Australia.

Specimens of *P. australis* have been examined which have the phragmocone in place (Fig. 6) and specimens of *P. oxys* with the conothecal striae showing. These striae and the position of the siphuncle have determined the ventro-lateral position of the grooves. It is to be noted that lateral lines [1] are not present extending from the posterior extremity of the grooves. In no case in this family do such lines continue from the ventro-lateral grooves when the latter have an existence independent of the dorso-laterals.

Genus Dimitobelus nov.

Definition.—Clavate belemnites provided with dorso-lateral grooves and lateral lines, both of which may be straight or somewhat curved. The alveolus may be normal, but generally a pseudalveolus with axial projection [2] is developed. A ventro-lateral groove may be formed by the furcation of the lateral lines but it never becomes isolated.

Genotype.—*Belemnites canhami* Tate.

Four species have been described all from Upper Albian beds: *D. canhami* (Tate),[3] *D. stimulus* Whitehouse,[4] *D. extremus* Whitehouse,[4] from the Rolling Downs, and *D. superstes* (Hector) [5] from the lower beds in New Zealand.

There is a considerable amount of variation in both *D. canhami* and *D. stimulus*, tending in each case towards the genus *Tetrabelus*. The morphologically simpler types (Fig. 2) have dorso-lateral grooves and lateral lines only, and the alveolus is often complete but showing a tendency towards the formation of a pseudalveolus by the non-pigmentation [6] of the shelly layers of the guard adjacent to the

[1] As Stolley has pointed out ("Die Systematik d. Belem," 11 *Jahrb. d. niedersächs. geol. Ver.*, 1919), there has been a great amount of confusion in the use of Belemnite terminology. The term "lateral lines" is here used as an equivalent of his "Doppellinien".

[2] The "Pseudoalveole" and "Nadelspitze" of Stolley ("Studien an. Belem. d. unt. Kreide Norddeut," ibid., vol. iv, 1911, p. 185, etc.).

[3] R. Tate, "Descr. new sp. Belemnite from Mesozoic strata, Cent. Aust.": *Trans. R. Soc. S. Aust.*, iii, 1880, p. 104, pl. iv. Specimens of *D. canhami* have been sent to me by Mr. M. S. Browne from a locality 23 miles S. of Tambo (Queensland) in association with an unnamed species of *Inflaticeras*. Elsewhere in this area the species has U. Albian associates. The species has been erroneously quoted from the Maryborough area in Queensland (Richards: *Rep. Aust. Ass. Adv. Sci.*, xiv, 1913, p. 182) where only the lower (Aptian) series is developed. The bed from which the specimens were derived represents the horizon at which *Peratobelus australis* occurs; and, since the two species were originally regarded as identical by Phillips, it is possibly the latter species which occurs in the bed.

[4] Described in a paper appearing shortly in the *Trans. Roy. Soc. South Australia.*

[5] See Woods, loc. cit., p. 12, pl. v, figs. 5–7.

[6] A similar early stage in the formation of the pseudalveolus occurs in the genus *Neohibolites*. See Stolley, loc. cit., 1911, p. 186.

conotheca. In other forms,[1] the lateral lines, instead of giving place anteriorly to a single groove, develop into a pair of grooves. The more dorsal line in each case deepens to form the dorso-lateral groove, while the ventral line continues as a second groove much less prominent than the dorso-lateral and diverging from it (see Fig. 3). This second groove is the ventro-lateral which in the genus *Tetrabelus* has an independent existence.

Another morphological change occurs in the alveolar region. The formation of a pseudalveolus takes place by the decalcification of the layers adjacent to the conotheca thus producing an enlarged conical cavity. During the life of the animal these decalcified layers must have been represented by some form of perishable tissue. Into this cavity there projects a needle-like spine which is a continuation of the axial part of the guard and extends from the base of the pseudalveolus to the protoconch. Stolley [2] has given a detailed description of this feature (referred to as the " Nadelspitze " by him, but here described as the " axial projection "). He regards it as an integral part of the " embryonic rostrum ". But a study of the feature in the present genus does not support this ; for in specimens where the pseudalveolus is merely represented by decolorized layers the outline of the axial projection is in some cases within the outline of the initial rostrum, while in other specimens it transgresses the lines of growth. The feature is thus not due to any embryonic condition but is impressed upon the guard in a later stage.[3]

These two morphological changes do not synchronize, for some specimens occur with no trace of ventro-lateral grooves but with a well-developed pseudalveolus.

Genus Tetrabelus nov.

Definition.—Clavate belemnites provided with dorso-lateral grooves and lateral lines, but having, in addition, independent ventro-lateral grooves. Alveolus normal.

Genotype.—*Belemnites seclusus* Blanford (Fig. 4).

Two species have been described, *T. seclusus* (Blanf.) [4] from the Lr. Utatur group of India and *T. kleinii* (Gürich) [5] from the Upper Albian portion of the Rolling Downs. A specimen from New South

[1] It has not been found possible (at present) to subdivide the lineage of *D. canhami* owing to the apparently perfect gradation. Thus the specific name is used to cover the range of variation limited by forms such as those of Figs. 2 and 3.

[2] Stolley, loc. cit., 1911, p. 186.

[3] It should be noted also that Prell has been led to the conclusion that there was no rostrum in the embryonic condition of the belemnites. See H. Prell, " Über d. Schale v. Spirula u. ihren Verwandten.," *Centralb. f. Min.*, etc., Bd. xxii, 1921, pp. 215–21.

[4] See Blanford and Stoliczka, " Ceph. Cret. S. India " : *Pal. Indica*, 1861, pp. 4 and 202, pl. i, figs. xliii–li ; pl. ii, fig. viii ; and also E. Spengler : *Beit. z. Pal. u. Geol. Österr-Ung. u. d. Orients*, xxiii, 1910, p. 153, pl. xiv, fig. vii.

[5] G. Gürich, " Jura. u. Devon. Foss. v. White Cliffs, Australia " : *Neu. Jahrb. f. Min.*, etc., B. Bd., xiv, 1901, p. 489, pl. xix, figs. 2–3.

Wales figured by Etheridge,[1] represents a third species. The genus is a direct descendant of *Dimitobelus*, the line of division occurring at the stage when the ventro-lateral groove ceases to be dependent on the dorso-lateral, but has an independent existence (now disconnected from the lateral lines).

Stolley [2] has suggested that *B. seclusus* is probably a member of his genus *Parahibolites* (genotype *P. duvaliaeformis* Stolley), but the absence of a ventral groove removes it from that genus and also from its family.

Genus Cheirobelus nov.

Definition.—Clavate belemnites with dorso-lateral grooves not continued as lateral lines. Rudimentary ventro-lateral grooves also exist converging to the posterior part of the dorso-laterals. Pseudalveolus developed.

Genotype.—*Belemnites lindsayi* Hector [3] (Fig. 5).

The genotype is the only species known, and is found in the Up. Senonian of New Zealand. No specimens with the phragmocone in place have been seen by the writer, so that the statement of the position of the grooves is based on the general shape of the guard and the greater extension of the shelly layers on one side of the pseudalveolus. The dorso-lateral grooves are deeply impressed; but the ventro-laterals are broad and shallow and can only be seen on close examination. They are evidently a rudiment of grooves with a more important function in their immediate ancestors.

Phragmocones.

Phragmacones have been seen in place in *Per. australis* and *Dim. canhami* only. But observations have also been made on the unaffected alveoli of *Per. oxys* and *Tet. seclusus*. All specimens of *Dim. stimulus*, *Dim. superstes*, and *Cheir. lindsayi* examined have had pseudalveoli developed. *Tet. kleinii* is only known at present from the genoholotype which is lodged in a private collection in Germany, but has been well figured by Gürich.

In *Peratobelus* the phragmocone is almost perfectly circular in cross-section. In *Dimitobelus* the section becomes slightly elliptical (the dorso-ventral axis greatest), while in *Tetrabelus* the elliptical outline becomes so extreme that in *T. kleinii* (as figured by Gürich) the dorso-ventral diameter is almost twice as great as the lateral. Measurements of the alveolar angle (lateral section) are as follows: *Per. australis*, 25°; *Per. oxys*, 26°; *Dim. canhami*, 20°; *Tet. seclusus*, 19°.

Distribution and Relations

The family, according to present knowledge, is restricted to the Indo-Pacific region.[4] In India it does not appear above the Lr. Utatur

[1] Etheridge, loc. cit., pl. ix, figs. 3, 4. [2] Stolley, loc. cit., 1919, p. 46.

[3] See Woods, loc. cit., p. 36, pl. xx, figs. 6–11.

[4] A single specimen found in the *Belemnitella mucronata* zone of Norfolk may, however, be a member of the family, but its position will be discussed in a future paper.

Group. It occurs in both divisions of the Rolling Downs, and in both New Zealand horizons. In Africa, it has not been recorded; but the account given by Kitchin [1] of the fragments in the Uitenhage beds suggests that it *may* have existed in African seas in the Neocomian, though no trace of it is found in subsequent Cretaceous beds of that continent. It has not been met with in the Cretaceous beds of West Australia nor in South America.

With regard to the general development of the family, nothing can be said of the relation of the earliest known genus (*Peratobelus*) to the succeeding *Dimitobelus*; for there is a large gap in the succession between the lower beds of the Rolling Downs (Aptian) and the succeeding (U. Albian) horizon. The variation of *Dimitobelus* towards *Tetrabelus* has already been mentioned. The three species of *Tetrabelus* show an apparent morphological progression in their characters. In *Dimitobelus* the ventro-lateral groove, when present, is less prominent than the dorso-lateral and the point of convergence of the two grooves appears to extend more and more towards the apex. The unnamed species of *Tetrabelus*, which has evidently just passed the bounding line between the two genera, shows a very long ventro-lateral groove tending to converge towards the dorso-lateral near the apex. From the figure given by Etheridge the two grooves are of almost equal strength, the dorso-lateral, however, being possibly a little more prominent. In *T. kleinii* all grooves are of equal impress, while in *T. seclusus* the ventro-lateral is much more distinct than the dorso-lateral.

Owing to the enormous gap between the horizon of *Tetrabelus* and that of *Cheirobelus* (due to incomplete succession) we have no direct evidence of the relations between the two genera. The presence of the rudimentary grooves in the latter genus, however, suggests an evolution from a four-grooved form, so that *Tetrabelus* may be an ultimate ancestor.

The family has a great resemblance to the *Hastatidae* of Stolley,[2] the main difference being in the absence of a ventral groove. But the writer does not believe that the two are related, for the earliest genus of the present family shows the widest difference from the *Hastatidae* in the entire absence of dorso-lateral grooves. Rather the resemblance is to be ascribed to convergence. The immediate derivation of the family is thus in doubt; and this is not surprising when one considers the paucity of known exposures of marine Jurassic and lowest Cretaceous beds in the Indo-Pacific region. The genus *Rhopalobelus* Pavlow [3] (Genotype *R. clavatus* Schloth. sp.) of the Middle Lias to the Aalenian is very suggestively akin to the present family. But it is unknown outside of Europe at present;

[1] F. L. Kitchin, "Invert. Fauna and Pal. Relations of the Uitenhage Series": *Ann. S. African Museum*, vii, No. 3, 1909, p. 210.

[2] In the opinion of the writer it is unnatural to remove the *Hastatidae* from their descendant, the *Belemnitellidae*, as a separate family as Stolley has done.

[3] This genus possesses antero-lateral grooves (four) only.

and the hiatus between its range and the lowest known horizon of the *Dimitobelidae* precludes anything more than a passing reference to it as a possible ancestor.

In conclusion, I should like to express thanks to the following institutions for the use of specimens: Geological Survey of Queensland, Queensland Museum, Geological Survey of India, University of Glasgow, Sedgwick Museum, and British Museum (Natural History).

On *Heptaphyllum*, a New Genus of Carboniferous Coral.

By Arthur E. Clark, B.A., Trinity College, Cambridge.

1. Introduction.
2. Heptaphyllum gen. nov.
3. Heptaphyllum gracile sp. nov.
4. Heptaphyllum magnum sp. nov.
5. Cryptophyllum.

1. Introduction.

A FEW years ago Mr. Carruthers [1] described an aberrant coral, *Cryptophyllum hibernicum*, from the Lower Carboniferous of Bundoran, Donegal. *Cryptophyllum* occurred in the Lower Calp shales, which are considered to be about at the horizon of Vaughan's C_2 to S_1 beds.[2] Another aberrant genus, *Heptaphyllum*, also from the north-west of Ireland—Lower Carboniferous shales, Sligo—forms the subject of this paper. *Cryptophyllum* is remarkable, first for the manner in which the earlier major septa appear—irregularly, and nearly simultaneously, instead of regularly, and in consecutive pairs, as is typical for Rugose Corals; and also in the development of only five septa instead of the normal six in the earliest growth stages. *Heptaphyllum*, as its name implies, develops seven septa in the young corallum. It resembles *Cryptophyllum* in having an early aseptate corallum, and in the way in which the earlier septa appear.

2. Heptaphyllum, gen. nov.

(ἑπτα "seven", φύλλον "a leaf", i.e. "a septum".)

Diagnosis.—The *corallum* is simple, conical or slightly cornute. The *major septa* are well developed. Seven major septa appear simultaneously at an early stage. There is a large *counter fossula*, with two primary major septa. The *cardinal fossula* is insignificant in mature stages. No *minor septa* are developed. *Tabulae* are present, but no *bessepiments*.

Distribution.—*Heptaphyllum* is abundant at the base of the Lower Carboniferous shales which overlie the Lower Sandstone anticline

[1] R. G. Carruthers, "A remarkable Carboniferous Coral": Geol. Mag. Vol. VI, 1919, p. 436.

[2] W. B. Wright, R. G. Carruthers, G. W. Lee, and Ivor Thomas, "On the Lower Carboniferous Succession at Bundoran, South Donegal": *Proc. Geol. Assoc.*, vol. xxiv, 1913, p. 70.

on the northern coast of Co. Sligo. It is here associated with a large assemblage of Zaphrentid corals, including *Zaphrentis omaliusi*, with *Z. ambigua*, *Z. densa*, *Z. delanouei*, Densiphyllids, and a ribbed form of *Caninia cornucopiae*. These beds may be referred to a Z_1 horizon. In the overlying beds *Zaphrentis delanouei* and *Z. densa* persist, in conjunction with *Zaphrentis koninckı* (with short minor septa), *Caninia cornucopiae* (with smooth epitheca) and *Michelinia*. These beds form a Z_2 subzone. A γ horizon is indicated by the appearance of *Caninia patula* and *Caninia cylindrica*, in conjunction with *Zaphrentis koninckı*, *Z. delanouei*, and *Z. densa*. In higher beds *Zaphrentis parallela* appears with *Michelinia megastoma*, and a typical C fauna.

There is nothing in the coral or brachiopod fauna of these beds to suggest a Viséan horizon, and the faunal contents of the underlying and overlying strata favour the view.

Genotype.—*Heptaphyllum gracile* sp. nov.

Remarks.—It is very difficult to classify such an aberrant form as *Heptaphyllum*. In earlier stages of development it bears a superficial resemblance to *Cryptophyllum* Carruthers, and *Plerophyllum* Hinde, in which there is usually no isolated septum in the counter fossula. It is doubtful, indeed, if *Heptaphyllum* should be included in the Rugosa, and it is very difficult to suggest a possible ancestor. Possibly it has been independently derived from a soft-bodied ancestor.

3. Heptaphyllum gracile sp. nov. (Fig. 7.)

Diagnosis.—*Heptaphyllum* of comparatively small size (length of corallum, 1 cm.; diameter of calicinal rim, 0·5 cm.), tapering to a fine proximal point. Broad counter fossula with two primary major septa which are usually loose and disconnected at their inner ends.

Description.—(1) External Morphology: The *corallum* is very small, slender and gently curved, tapering proximally to a fine point. There is usually slight longitudinal ribbing on the *epitheca*, especially in the calicinal region. Growth is fairly regular, but constrictions of growth sometimes occur. Interruption in the continuity of the epitheca (rejuvenescence) does not take place. There are no annular striations.

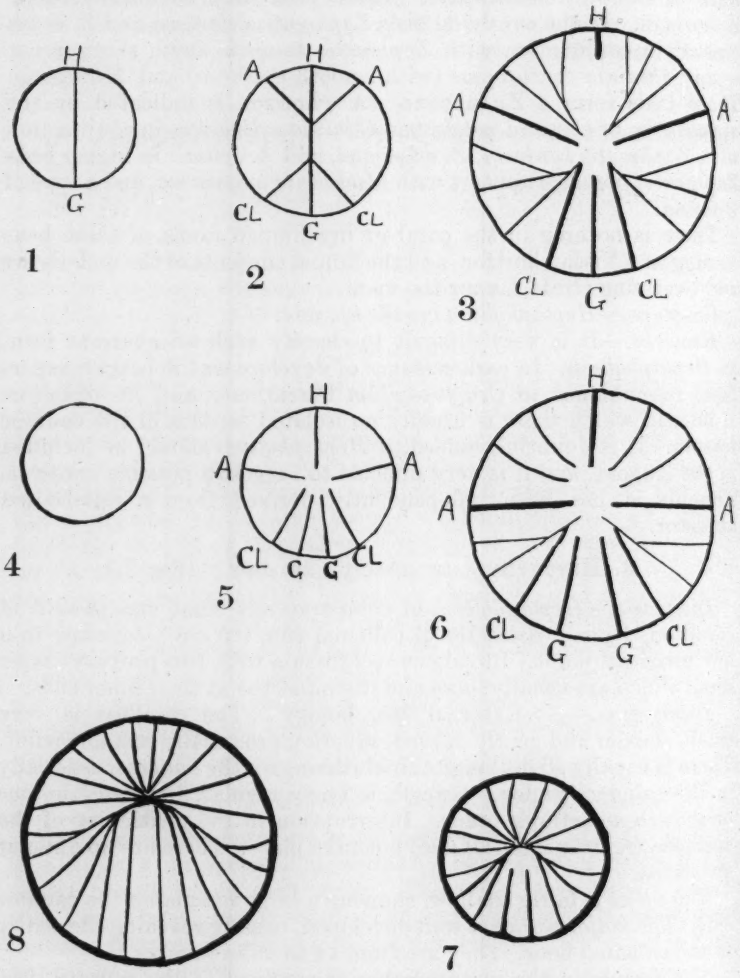
The *calice* is fairly shallow, showing a large fossula on the counter side. The *major septa* are well developed, usually reaching the centre of the calicinal floor. They are from 14 to 16 in number.

The *fossula* in the mature calice is confined to the counter side, and is very large, wide peripherally, and diminishing towards the centre of the corallum. The outline is even and continuous, there are no constrictions, and usually no expansion at the inner end. The walls of the fossula are septal.

The *cardinal fossula* is inconspicuous, and the cardinal septum hardly differs from the metasepta.

No minor septa are developed.

(2) Internal Morphology.—(*a*) *Transverse sections*: Sections through the mature stage of the corallum show a structure similar to that of the calice, the two adjoining septa on the counter side



FIGS. 1–3.—Development of a normal Rugose Coral (Carruthers).
„ 4–6.—Development of *Heptaphyllum*.
„ 7.—*Heptaphyllum gracile* gen. et sp. nov.
„ 8.—*Heptaphyllum magnum* sp. nov.

usually lying loose and disconnected at their inner ends. Sections through younger portions of the corallum show these septa leaning against the adjoining septa, and the counter fossula is smaller. In

still younger sections the cardinal fossula may be detected and the counter fossula is less conspicuous. Sections through the calice show the septa on the cardinal side at their full development, but the septa on the counter side becoming shorter and finally disappearing. (*b*) *Vertical sections*: Tabulae are sporadic and irregular, and no dissepiments are developed.

Distribution.—As for genus.

Type Specimen.—Holotype in the Sedgwick Museum, Cambridge. Material also in the British Museum (Natural History).

Ontogeny.—In *Heptaphyllum gracile* the proximal portion of the corallum tapers gently to a minute tip, so that the earliest stages of development can usually be traced without difficulty and the primary septal formation determined. There is no broad basis of attachment as in many corals. At first the corallum is purely tabular: There are no traces whatever of primary septa (Fig. 4). *Cryptophyllum* has a similar aseptate condition in the young corallum. In typical Rugosa a single axial septum is developed in the earliest stages (Fig. 1) stretching across the corallum from wall to wall, later dividing to form the cardinal and counter primaries (H and G).

In the next stage of growth *seven* major septa are developed simultaneously. It is very difficult to state definitely what these seven septa really are. As they appear simultaneously there is no criterion by which to judge their relative status. The first explanation which suggested itself was that they are all primary septa, consisting of a single cardinal septum which is never very conspicuous; the usual pairs of alar septa on the cardinal side, and two counter laterals on the counter side; and *two* counter septa lying together in the counter fossula (Fig. 5). These two septa are always well developed, and usually become loose and disconnected at their inner ends as growth proceeds.

If the theory that these seven are primary septa including two counters is accepted, the counter fossula is bounded by the counter laterals (CL, Fig. 6).

The cardinal septum, which is short, lies in a well-marked cardinal fossula, which tends to disappear in later stages, when the cardinal septum no longer differs from the adjoining metasepta. As the cardinal fossula disappears the counter fossula becomes conspicuous, and the inner or more central boundaries are sometimes formed by the long curved metasepta in the alar sectors (A–CL, Fig. 6).

During development the alar septa usually move towards the counter side, thus enlarging the cardinal sectors (A–H, Fig. 6), and making the alar sectors (A–CL) correspondingly smaller. Subsequent metasepta are added normally; that is to say, the earliest metasepta in the cardinal sectors lean against the alar primaries, and subsequent septa are inserted nearer the cardinal septum, and similarly in the alar sectors.

The grouping of the metasepta proves that the large fossula is

indeed the counter fossula. The alar fossula can usually be detected, though it is rarely conspicuous. The alar septa can thus be determined even in the mature stages, and the determination corroborated by the grouping of the earliest metasepta.

It appears, on comparing *Heptaphyllum* with other simple Rugose Corals, that there is a general tendency for the counter fossula to be developed at the expense of the cardinal fossula as growth proceeds ; and that *Heptaphyllum* presents an extreme case of what is seen in certain species of *Zaphrentis*. For example, in *Zaphrentis delanouei* the cardinal fossula is usually longer and more pronounced in the earlier stages of development than in later stages ; in sections cut immediately beneath the mature calice the fossula is shorter and the cardinal septum tends to disappear. The counter structure is sometimes rendered more conspicuous by the development of two minor septa between the counter and counter-lateral primaries, and by the addition of stereoplasmic thickening to the counter septum. Again, in *Zaphrentis ambigua* the earlier stages are identical with its " parent ", *Zaphrentis omaliusi*, with an inconspicuous counter fossula. It is only in the mature stages that the large counter fossula, which is characteristic of the species, is developed.

4. Heptaphyllum magnum sp. nov. (Fig. 8.)

Diagnosis.—Heptaphyllum of comparatively large size (length of corallum, 2·5 cm. ; diameter of calicinal rim, 1·3 cm.), with a wide basis of attachment. Long slender counter fossula, which extends to about two-thirds of the diameter of the corallum, with two primary major septa which are never loose and disconnected at their inner ends.

Description.—(1) External Morphology : The *corallum* is gently curved, expands rapidly in the calicinal region, and has a large basis of attachment. The *epitheca* has strongly marked longitudinal ribbing, but no annular striations. Growth is regular and there are no constrictions of growth or rejuvenescence. The calice is not known.

(2) Internal Morphology : (*a*) *Transverse Sections* : There are twenty-two major septa in the fully grown coral. In the mature stages the long, slender *counter fossula* is very conspicuous with two long slender primary septa. There is no apparent cardinal fossula, another cardinal septum resembles the surrounding septa. The four metaseptal groups are clearly marked. As in *H. gracile*, the younger stages have a conspicuous cardinal fossula, and but a rudimentary counter fossula. (*b*) *Vertical Sections* : The *tabulae* are more regular than in *H. gracile*. No dissepiments are developed.

Distribution.—As for genus.

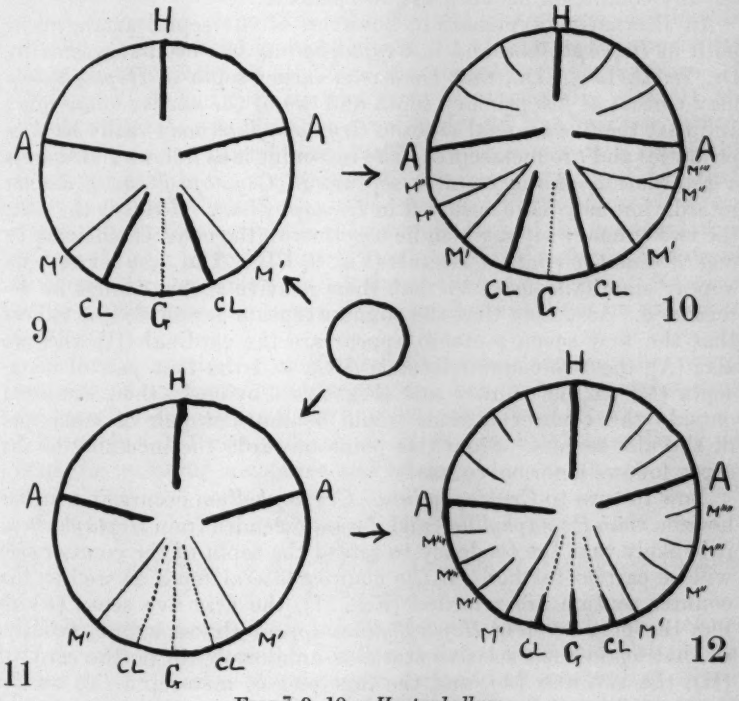
Type Specimen.—Holotype in the Sedgwick Museum, Cambridge. Material also in the British Museum (Natural History).

Ontogeny.—In *Heptaphyllum magnum* the initial stages of septal development are obscured by the large size of the proximal portion.

In the earliest stage observed all the primary septa and some of the metasepta had already appeared. The cardinal fossula was conspicuous, bounded by short metasepta and divided by a short cardinal septum. The counter fossula was also present as a long thin fossula, with two adjoining primary septa having their inner ends fused with the central boundary of the fossula.

As growth proceeds the cardinal fossula diminishes in size and becomes inconspicuous, while the counter fossula becomes more prominent. In mature stages the counter fossula extends to about two-thirds of the diameter of the corallum.

As there are again four well-developed septa on the counter side and three on the cardinal side, as in *H. gracile*, it is reasonable to assume that these seven septa were developed first as in the other species.



FIGS. 9, 10.—*Heptaphyllum.*
„ 11, 12.—*Cryptophyllum.*

5. CRYPTOPHYLLUM.

The similarity between *Heptaphyllum* and *Cryptophyllum* in the formation of the earlier septa suggests that these two genera may be connected. The early aseptate condition of the corallum; the

irregular and almost simultaneous appearance of an unusual number of early septa ; the presence of two primary septa together on the counter side instead of a single counter septum ; these are all points of resemblance between these two remarkable forms.

In the description of *Cryptophyllum* (Carruthers, loc. cit.) it has been claimed that five primary septa are formed in the first instance, and that in some cases a small retarded counter septum ultimately appears, and that two minor septa are developed between the counter and counter lateral primaries ; all three appearing after the insertion of metasepta. These three septa occur only in certain specimens ; they are not invariably present. No other minor septa appear. In *Heptaphyllum*, on the other hand, it has been observed that *seven* septa appear at an early stage, and it has been assumed that two of them are counter septa. If these views are correct it is difficult to see any connexion between the two genera.

An alternative explanation, however, of the septal arrangement both in *Heptaphyllum* and in *Cryptophyllum* has been suggested by Dr. W. D. Lang, i.e., that the seven earlier septa of *Heptaphyllum* may consist of *five* primary septa and *two* of the earlier metasepta ; and that the five original septa in *Cryptophyllum* may really be *three* primaries and *two* metasepta. The reasoning is as follows : If there is a retardation of the counter septum in *Cryptophyllum*, a similar retardation may have occurred in *Heptaphyllum*. If this is the case, the two primary septa which lie together on the counter side may be regarded as the counter laterals (Fig. 9, CL). The first seven septa appear simultaneously, so that their relative status cannot be determined. Assuming that the counter septum is retarded, it follows that the first seven septa to appear are the cardinal (H), the two alar (A), the two counter laterals (CL), and the first pair of metasepta (M) on the counter side (Fig. 9). Obviously then the septa outside the counter laterals would be the first pair of metasepta of the alar sectors. From this point onwards the incoming of the septa follows a normal course.

Now to turn to *Cryptophyllum*. *Cryptophyllum* occurs at a higher horizon than *Heptaphyllum*, and if it is descended from *Heptaphyllum*, it is likely that the tendency to retard the septa of the counter side will be carried further. If the counter lateral septa as well as the counter septum are retarded (Fig. 11), the first five septa (which like the first seven of *Heptaphyllum* appear almost simultaneously, so that again their relative status is unknown) will be the cardinal (H), the two alar (A), and the first pair of metasepta (M) on the counter side. Subsequent insertion of metasepta follows a normal course. Occasionally, that is in certain individuals, the three little septa, which were regarded as the belated counter septum (in the centre), and two minor septa ultimately appear in the counter fossula (Fig. 12). But the two little septa developed in connexion with the newly found counter septum might be regarded as the belated counter laterals rather than an isolated pair of minor

septa, especially as no other minor septa appear in *Cryptophyllum* or in *Heptaphyllum*.

Specimens of *Cryptophyllum* were divided into two groups: (1) those in which no belated septa appeared; and (2) an "advanced" group in which the belated septa ultimately made their appearance. But if the view that the counter laterals as well as the counter septum have been retarded is correct, then the former group in which further retardation of septa on the counter side occurred must be regarded as the more "advanced".

According to this theory, then, *Crpytophyllum* may have been derived from *Heptaphyllum* by the further retardation of septa on the counter side, and by the shortening of the metasepta. The septal arrangement (according to this theory) both in *Heptaphyllum* and in *Cryptophyllum* are shown in Figs. 9 to 12. Against this theory it may be argued that in *Cryptophyllum* the two little septa which appear in connexion with the retarded counter septum are usually, if not invariably, smaller than the counter septum, and sometimes do not occur at all when the counter septum appears. If *Cryptophyllum* has been derived from *Heptaphyllum*, in which the counter laterals are strongly developed and the counter septum (according to the second view) rarely if ever occurs, it is reasonable to assume that in *Cryptophyllum* the counter laterals would be more fully developed than the counter septum. Furthermore, it is not unusual to find an early minor septum in each of the counter lateral sectors (CL–G) in some Rugose corals, and this is sometimes useful as a criterion by which to determine the counter side. No other minor septa, however, occur either in *Heptaphyllum* or in *Cryptophyllum*.

So far the specimens of *Heptaphyllum* examined have not shown any sign of a retarded counter septum, but probably too few have yet been investigated to make any definite statement.

In conclusion, I wish to thank Mr. H. Woods, F.R.S., and Dr. W. D. Lang, for valuable assistance and advice.

"Farey's Grit."

By J. Challinor, M.A., F.G.S., University College of Wales, Aberystwyth.

THE present paper deals briefly with the historical aspect of the boundary between the Pendleside Series and the Millstone Grit Series in the Roches district and surrounding country of North Staffordshire some 4 miles north-east of Leek; and particularly with the term "Farey's Grit". It seems to me probable that the difficulties as to limitation and classification of these divisions of the Carboniferous System are by no means limited to the small area with which I am familiar. The substance of this paper is derived from the works listed at the end, and has formed itself as a result of attempts to map the rocks in detail.

Farey's book, published in 1811, was the great pioneer work in the study of the geology of the Peak District. His classification and terminology may first be mentioned (see table towards the end of this paper). He drew the base of the Coal Measures at the top of the most constant and conspicuous grit bed and called this bed "Millstone Grit", confining the term to it. A higher grit bed (and the intervening shale), which he included in the Coal Measures, has for long been classed more naturally with the Millstone Grit. He took the top of the Carboniferous Limestone at the top of the massive limestones and he has been followed by every authority, with one partial exception (Garner), to the present day. The rocks between the massive limestones and the "Millstone Grit" he called the "Limestone Shale", grouping these with the "Millstone Grit" as the "Gritstone and Shale" Series. This "Limestone Shale" he described as being mainly shale, but containing much sandstone ("grit") and limestone, and he uses the following words (1811, pp. 228 and 229):—

> "This great Shale . . . is subject to great and curious anomalies the first and most general of which are, accidental beds of fine-grained Siliceous Freestone, very full of Mica, in minute flakes, and stained with various concentric rings of different shapes and shades of yellow and red. This stone, which I call the *Shale-Freestone*, or Shale Grit, from the circumstance of its always alternating with Shale . . . But the most extraordinary anomaly attending this great shale is the great masses and accidental beds of dark blue or black limestone which it produces, and which therefore I call the *Shale-Limestone* . . ."

I wish to draw attention particularly to his term "Shale Grit". He is here evidently alluding to the sandstones in general which occur in his "Limestone Shale"—the well-known conspicuous sandstones now generally called the "Pendleside Sandstones" or "Crowstones". But Hull and Green (e.g. 1864, p. 247) confined Farey's "Shale Grit" to a supposed particular grit at the top of the "Yoredale Rocks" (Pendleside Series). The "Shale Grit" horizon, as restricted by Hull and Green, has been mentioned in nearly all references to the geology of the neighbourhood, so that it seems to have become firmly embedded in geological literature. Green, in 1887, repeated his interpretation of Farey's "Shale Grit" in even more definite terms than before, and made it the base of the Millstone Grit. In addition to the above quotation, the following reasons may be stated in support of the contention that the restricted use of the terms "Farey's Grit", "Shale Grit", or "Yoredale Grit" (which are synonymous) is unwarranted:—

1. Farey (1811, pp. 35, 46) calls the strata on the top of Gun Hill and Morridge ("Moredge") "Shale and Shale Grit". These beds appear to be undoubtedly Pendleside shale and sandstone well down in the series (see Hull and Green, 1864, p. 259).

2. Hull and Green's restricted "Farey's Grit", is admittedly

ill-defined. On the Survey map (1864) it is never traced far continuously, although the " Fourth " and " Fifth Grits " have in places been boldly drawn in on slender evidence. All the references to it in the district confirm the vagueness of its meaning.

3. I have been unable to find any evidence in the field of a continuous bed of grit in the position assigned by Hull and Green to " Farey's Grit ".

4. Finally, it is difficult to suppose that Farey should in his day fix on an ill-defined bed for such conspicuous mention whereas the general Pendleside sandstones are just the beds that strike the eye.

It may be mentioned that De Rance (1898, p. 22) used the term " Shale Grit " in too extended a sense, to include the whole of Farey's " Limestone Shale ". There has thus been much confusion about this term, and its correct interpretation in the sense originally intended by Farey is important, if only for the fact that the base of the " Shale Grit of Farey " or " Farey's Grit " as interpreted by Hull and Green (Green appears to have been chiefly responsible) has been used as a horizon dividing the Millstone Grit and the Pendleside Series (e.g. Green, 1887 ; Hind, 1910 ; and Geological Survey Map, 1910). The fact is, however, that there is no satisfactory lithological horizon at which to draw the boundary between the two series in this area, and I suspect this to be the case elsewhere. The Pendleside Series passes up quite gradually into the Millstone Grit, the chief change being the increase in thickness and regularity of the grit beds. If it is necessary to make a division between the two series in any area, this, as far as I can see, can only be done naturally by taking the base of the lowest well-marked grit bed as the base of the Millstone Grit. In this area the base of the " Third " or " Roches Grit " would be such an horizon, though even within this small district the grit beds below (the " Fourth " and " Fifth Grits ") are locally conspicuous and in other areas appear to be very well marked. Thus on lithological grounds, the division would be made at different horizons in different places.

Turning to the fossils in the hope of finding a satisfactory dividing horizon between the two series, these certainly appear more promising than the rocks themselves. A series of goniatite zones was worked out by Hind, but these still left his Pendleside Series without any precisely defined upper limit. The change in the fossils (in the fossil animals at least) as the Pendleside Series is traced up into the Millstone Grit is one of increasing scarcity due to the gradual oncoming of unsuitable conditions rather than of a widespread and sudden alteration in character. It is, however, remarkable that Kidston (1923, p. 10) has recently stated that in the Congleton-Leek district (to the west of the area under discussion) Upper Carboniferous plants extend down to about 50 feet below the " Fifth Grit ", then comes 60 feet of barren rock, and then suddenly appears a typical Lower Carboniferous flora. This is about the horizon of the base of Hull and Green's " Farey's Grit ". " There is no admixture of species

Lithological Divisions.	Farey, 1811.	Jukes, 1839.	Garner, 1844.	Wardle, 1862.	Hull & Green, 1864, 1866.	Hind, 1910.
Shales and Sandstones with the chief coal seams.	Coal Measures.	Coal Measures.	Coal Measures.	Coal Measures.	Coal Measures.	Coal Measures.
Grit ("1st Grit," "Goldsitch Grit"). Shale.	Gritstone and Shale. Millstone Grit.	Gritstone and Shale.		Millstone Grit. Rough Rock (U. Millstone Grit).	Millstone Grit.	Millstone Grit.
Grit ("3rd Grit," "Roches Grit"). Shale. Grits ("4th" and "5th Grits").	Limestone Shale.	Gritstone.	Millstone Grit.		Yoredale Rocks.	Pendleside Series.
Shales, Grits, and some Limestones. Shale Hull & Green's "Farey's Grit". Shales and Limestones (chiefly).		Shale.	Carb. Limestone or Mountain Limestone. Limestone Shale.	Limestone Shale.		
Massive Limestones.	Limestone.			Carboniferous Limestone.	Carboniferous Limestone.	Carboniferous Limestone.

in either case, nor has any unconformity been observed between the two palaeontological provinces."

However, until it is more fully worked out, and its upper limit more precisely defined, the Pendleside Series must remain an unsatisfactory stratigraphical division, and it must be almost impossible to separate it from the Millstone Grit above. The lower limit is generally more definite both lithologically and palaeontologically, though it is a curious fact that the passage from the massive limestone to the Pendleside Series is usually obscure and seldom seen in continuous section. Again, it is still uncertain what rocks in areas outside the southern Pennines are the representatives of this series. The vexed question as to the equivalence or non-equivalence in time of the Pendleside Series of Hind and the Yoredale Series of Phillips is still not definitely settled, though present day opinion favours the view that they are, at least for the greater part, contemporaneous.

In conclusion, a table showing the classification and terminology used by the chief authorities serves to show the great instability of the boundary horizons and the nomenclature in the history of the study of the rocks in this district.

LIST OF BOOKS, PAPERS, AND MAPS.

J. Farey.—1811. *General View of the Agriculture and Minerals of Derbyshire.*

J. B. Jukes.—1839. "Geology of the Northern Part of the County of Stafford": *The Analyst*, vol. ix, pp. 233–40.

R. Garner.—1844. *Natural History of the County of Stafford.*

T. Wardle.—1862. "On the Geology of Leek and the District": Sleigh's *History of Leek*, pp. 225–98.

E. Hull and A. H. Green.—1864. "On the Millstone Grit of North Staffordshire, etc.": *Q.J.G.S.*, vol. xx, pp. 242–67. 1866. "Geology of the Country round Stockport, Macclesfield, Congleton, and Leek": *Mem Geol. Surv.*, and Map 1 in. to 1 mile, Sheet 81 S.W. (1864).

A. H. Green and others.—1887. "The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire", 2nd ed.: *Mem. Geol. Surv.*

C. E. De Rance.—1898. "The Making of Staffordshire": *Trans. North Staff. Field Club.* vol. xxxii, pp. 17–42.

W. Hind and J. A. Howe.—1901. "The Pendleside Series": *Q.J.G.S.*, vol. lvii, pp. 347–404.

W. Hind and others.—1903. "Excursion to North Staffordshire": *Proc. Geol. Assoc.*, vol. xviii, pp. 173–84.

W. Hind.—1910. "Staffordshire": *Geology in the Field*, pp. 564–91.

Geological Survey.—1910. ¼ in. map (revised), Sheet 11.

W. Hind.—1918. "On the Distribution of the British Carboniferous Goniatites": GEOL. MAG., Vol. LV, pp. 434–50.

A. Gilligan.—1919. "The Petrography of the Millstone Grit of Yorkshire": *Q.J.G.S.*, vol. lxxv, pp. 251–94.

J. Challinor.—1921. "Notes on the Geology of the Roches District": *Trans. North Staff. Field Club*, vol. lv, pp. 76–87.

R. Kidston.—1923. "Fossil Plants of the Carboniferous Rocks of Great Britain": *Mem. Geol. Survey*, Palaeontology, vol. ii, pt. i.

Note on Fossiliferous Strata on the Galapagos Islands explored by W. H. Ochsner of the Expedition of the California Academy of Sciences in 1905–6.

By W. H. DALL, A.M., D.Sc., LL.D., Palaeontologist, United States Geological Survey.

ONE of the most interesting results of the exploration of the Galapagos Islands by the Academy's expedition was the discovery of sedimentary fossiliferous strata on several of the islands. A report was prepared with descriptions of the fossils by the writer in 1916, but the publication so far, has been delayed.

The interest attaching to this discovery is so great, the islands having been regarded hitherto as entirely eruptive, that it seems desirable to put on record a brief abstract of the results, as recorded by Mr. Ochsner.

The fossiliferous beds are exposed in the face of cliffs, and were reached by Mr. Ochsner with difficulty and even danger.

The oldest beds lie on the east coast of Indefatigable Island, on a line due east of the centre of the island, showing two distinct zones, the older at sea-level, the upper separated by an interval of non-fossiliferous sediment. Analogous beds were found on Seymour Island, which lies north of Indefatigable, and is separated from it by recent faulting.

More recent beds occur as islands between tongues of lava just north of the harbour at Villamil anchorage, Albemarle Island, approximately 40 to 50 ft. above sea level. The matrix is largely composed of grains of disintegrated coral.

The lower zone at Indefatigable and Seymour Islands yielded eight species, of which six are extinct and four definitely new.

The upper zone at the same localities yielded sixty-nine species, of which twenty-seven are still living and twenty-four new.

From the more recent beds on Albemarle Island fifty species were collected, of which three are indeterminable, and thirty-two are still living in the Panamic fauna.

The oldest beds are tentatively regarded as Pliocene, the later as probably old Pleistocene.

The analogy of these beds with others observed in the Hawaiian Islands (Oahu), Fiji, Lower California, and even on the north shore of Norton Sound, Alaska, is marked, so far as the succession and presumable age is concerned.

By eminent specialists the recent fauna of the Galapagos is regarded as of American derivation modified by long isolation.

The fossil mollusca collected, with hardly an exception, show typically American characteristics. The fauna is tropical, but there is nothing of a characteristic Indo-Pacific nature, though some of the species belong to groups widely distributed in tropical seas of the world. There is no genus represented in the series which is not

found in American waters, a few being Antillean, the vast majority belonging to the western shores of the two Americas.

The Pleistocene bed contained a new species of *Pholadomya*, the only Antillean genus of the collection not known to be represented in the recent fauna of the Pacific coast.

Yet the fauna of Clarion Island, the nearest island to the west, is clearly Indo-Pacific. The deposits show that as early as the Pliocene the Galapagos Islands were in existence and perhaps not very much less in extent than at the present time.

REVIEWS.

ANCIENT HUNTERS AND THEIR MODERN REPRESENTATIVES. By W. J. SOLLAS, Sc.D., F.R.S., Professor of Geology and Palaeontology in the University of Oxford. Third edition, 1924. pp. i–xxxvi, 1–697. Macmillan and Co. Price 25*s.* net.

THE first edition of this well-known book appeared in 1911, and the second four years later.

The author, in his preface, remarks that " the unavoidable delay which has occurred in the preparation of the present edition is the less to be regretted since it has afforded an opportunity of incorporating the latest additions to our knowledge and of setting forth the subject in a new and enlarged perspective ". Readers who compare this edition with the two previous ones will see how fully the author has availed himself of this opportunity, bringing the book thoroughly up to date.

With the new material comes new trouble. The chronological classification of the deposits containing relics of man has been drawn up after study of different kinds of evidence, and each kind may have its own nomenclature. Thus, as a result of study of the sequence of human cultures, we have the classification into Strepyan, Chellean, and others. Consideration of climatic changes is responsible for such terms as Mindel, Günz, and the like, and now, in connexion with changes of level of land and sea, a third set of terms—Sicilian, Milazzian, Tyrrhenian, and Monasterian—is introduced, and until a unification of nomenclature is reached the student is apt to be bewildered. Professor Sollas goes a long way in the direction of such unification, but the last word has not yet been spoken.

In talking of the relics of man, we must bear in mind that the word " man " is a popular name introduced into scientific writings, and has accordingly been used there with more than one meaning, and the author bids us distinguish between man and hominids, the former being only one of the latter.

It will not be necessary to review the book in detail now that it has reached a third edition ; it must suffice to draw attention to some of

the more important alterations in the present issue, and especially those which have direct geological bearing.

In the first chapter, as in previous editions, glaciation and river-terraces are considered; but we now meet with an account of the researches of General de La Mothe and Professor Depéret on old high-level sea-beaches and their significance in connexion with pre-historic chronology. Many of the later changes in the volume are connected with these modern investigations.

In the next two chapters matters are considered which are still subjects of acute controversy. Naturalists are yet in doubt as to whether *Pithecanthropus* should be placed with the hominids or the anthropoid apes. The stone relics of man or hominid have been claimed to occur in Miocene and Pliocene beds. The author does not seem disinclined to accept certain chipped stones from the Upper Miocene of Cantal as artefacts, and speaks with a more certain note of chipped flints from the Pliocene of the Ipswich district, discovered by Mr. Reid Moir. But notwithstanding the fact that these have been accepted as artefacts by distinguished French anthropologists, one seems to detect a lurking doubt in Professor Sollas' mind.

Chapter IV contains a vivid description of a modern race, the Tasmanians, and three later chapters deal with the Australians, the Bushmen, and the Eskimos respectively. In these there is much new material, especially in the account of the Eskimos, for which the author acknowledges his indebtedness to V. Stefansson.

In Chapters V–XIII inclusive a discussion of the various Palaeolithic periods and cultures from Chellean to Azilian appears, with intercalation of the accounts of the recent peoples above noticed. Here we are on less controversial ground than in the opening stages, and there is less change from the earlier editions than in other parts of the work, though noteworthy additions occur. For instance, the author still uses, as he has before used, the classic work of V. Commont in the Somme Valley as a basis for comparison, but he now supplements this by an appeal to Depéret's work, and accordingly one is almost startled suddenly to read, on p. 150: "The Sicilian terrace of the Thames is very clearly defined, and has been studied at Boar's Hill, near Oxford." This may be taken as a sample of the manner in which the new material is introduced here and there through the body of the work. The example is chosen for two reasons. In the first place because the evidence of glaciation by floating ice which has brought erratics from the Devono-Cornish peninsula will be of great interest to geologists, and secondly because the information concerning this part of the Thames valley is partly based upon the observations of the rising school of young Oxford prehistorians which has sprung up owing to the genius of the Oxford Professor.

Space forbids us to cite other examples of new matter in the present edition. Enough has been said to indicate that the new edition should be read even by those who are conversant with the contents of the former ones.

In the final chapter on Chronology, the Professor's conclusions as to this matter are expressed in tabular form with reference to the beds of East Anglia (p. 642) thus :—

Monasterian .	Upper .	Upper Boulder Clay (Mousterian).	
	Lower .	Middle Glacial Sands (Mousterian).	
Tyrrhenian .	Upper .	Lower Boulder Clay.	
		Arctic Freshwater Bed.	
		Leda myalis Bed.	
	Lower .	Upper Freshwater Bed.	
		Upper Forest Bed.	
		Lower Freshwater Bed (Chellean).	
Milazzian ? .	Upper .	Upper Weybourn Crag	
	Lower .	Mammaliferous Crag.	
Sicilian ? ? .	Norwich Crag.		

The Acheulean is here not mentioned, but two pages previously he suggests that a warm Acheulean industry undoubtedly occurs in the Lower Monasterian stage. As he elsewhere includes the Red Crag as a deposit to be taken with the Norwich Crag, and also argues that the last glaciation with a somewhat less severe interval in its middle extends from Mousterian times to the end of the Magdalenian period, we have here in a condensed form the latest and most successful attempt to correlate earth-movements, climatic changes, and sequences of human cultures.

There are many matters of detail in the book to which exception might be taken, indeed, certain remarks dropped by the author seem to indicate that he himself feels this. Such exception might be taken were we dealing with an ordinary textbook. But the book is not only educative, it is also inspiring, and it would be ungracious to seek flaws in so harmonious a whole.

The style is brilliant, the presentment of the subject clear, and while general readers will enjoy and profit by perusal of the book, the advanced student will find in the treatment of the more intricate problems ample material for thought. The work is indeed not only suited to the teaching of anthropogeology, but also a very valuable means towards the making of anthropogeologists.

J. E. M.

Fortschritte der Mineralogie, Kristallographie und Petrographie. Vol. VIII. pp. 234. (Deutsche Mineralogische Gesellschaft.) Jena : Gustav Fischer, 1923.

THIS volume contains a report of the meeting of the German Mineralogical Society at Leipzig in September, 1923, most of which has already appeared in our pages, together with five special papers on mineralogical and geological subjects. Of these the most noteworthy is one by W. Wetzel of Kiel, which consists of a very comprehensive review of recent progress in sedimentary petrography, with several useful bibliographies. A good deal of